New Scientist

WEEKLY 22 October 2022

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GRETA THUNBERG'S GUIDE TO A BETTER WORLD

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A NEANDERTHAL FAMILY

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Virtual event

Memory, the brain and who we are

How do our brains store past experiences to make us who we are? Why can memories feel so real? Are there such things as "true" and "false" memories? Psychiatrist Veronica O'Keane offers a new way of thinking about our personal experiences. Watch online at 6pm GMT/1pm EST on 10 November. Also available on demand.

newscientist.com/events

Academy

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Health and happiness can be difficult to achieve. In this course, you will learn from leading experts in psychology, fitness and nutrition about changing bad habits for good ones, and how the food we eat and exercise we take affect both our physical and mental health. You will also hear about the importance of living in the moment to overcome negative thoughts. Join now for £99.

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Podcast

Weekly

Podcast editor Rowan Hooper talks with writer Lucy Jones and researcher Gesche Huebner at University College London about the effects of climate change on mental health. The team also shines a spotlight on the world's least-studied penguin and its unusual egg-laying habits. Plus, an artificial intelligence has found a novel way to multiply numbers.

newscientist.com/nspod

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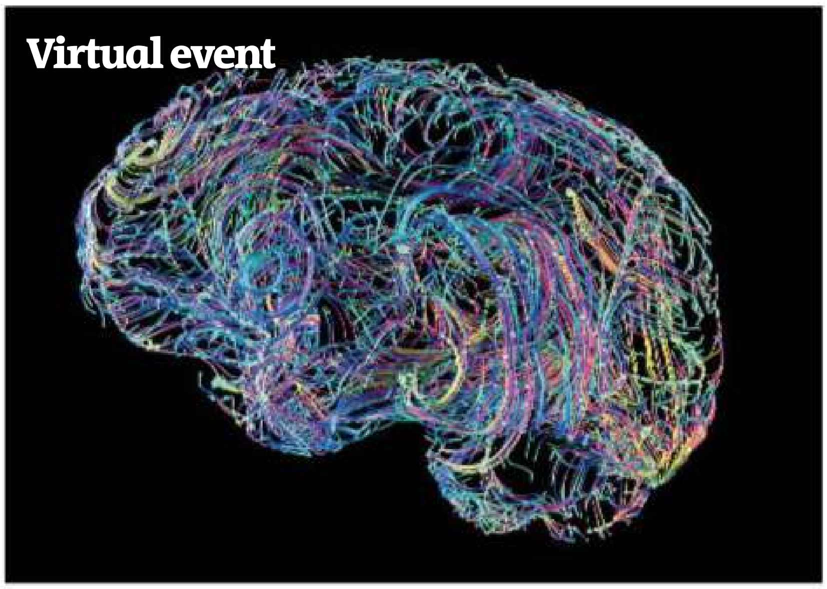
Penguin puzzler The erect-crested penguin lays too many eggs



DESIGN CELLS/GETTY IMAGES

Seat of reality Find out why memories seem so vivid

Video

Robot dancers

Head over to our YouTube channel for a behind-the-scenes look at *Prehension Blooms*, a dance piece that was performed in London earlier this month. The show starred human performers alongside robots inspired by sand-dwelling animals like the horseshoe crab, the movements of which could be influenced by audience members.

youtube.com/newscientist

Newsletter

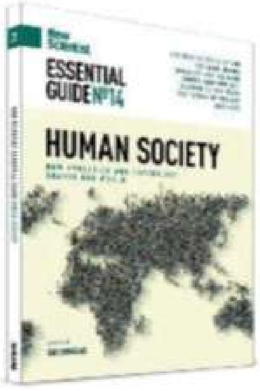
Our Human Story

While on a New Scientist Discovery Tour of Turkey's archaeological heritage, Michael Marshall considers the ways in which organised societies developed in the past – and the evidence that humans could build complex monuments or cities even in the absence of an elite ruling class.

newscientist.com/our-human-story

Podcast

> **"I can't get my head around this. How can there be a new way to multiply?"**



Essential guide

How did evolution and psychology shape human society? We differ from most other animals in that we cooperate with strangers as well as with family members. Learn about how this happened – and the tensions it has created – in the latest *New Scientist Essential Guide*. Available to purchase now.

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Star potential

Despite a history of hype around fusion, there is good reason for renewed optimism

WHERE is the hottest known spot in the solar system? The surprising answer is that it is in the village of Culham in Oxfordshire, UK, beside the river Thames. This is the home of the Joint European Torus (JET), a record-breaking fusion facility. When powered up, plasma rushes around the reactor's core at 150 million °C, hotter than the centre of the sun.

JET is a poster child for the backers of fusion power, the technology that has, for decades, been touted as a solution to our energy and climate woes. The process yields vast amounts of energy, but no carbon dioxide and little other waste. If we could tame it, we would have a virtually unlimited supply of clean energy.

"If" is key here. After decades of research, no electricity has ever been generated by a fusion reactor. That might make attentive readers of this magazine wonder why it has had so much coverage lately. In 2020, our cover story took a deep dive into how artificial intelligence could help the quest for fusion power. In August this year, we reported the milestone that the National Ignition Facility in the US had created a fusion reaction energetic enough to be self-sustaining. This week, we are at it again, weighing up the claims of a multitude of start-ups that are promising to deliver commercial fusion power in about 10 years (see page 38).

> "We are reminded that any alternative to fossil fuels is worth exploring"

One reason to keep an eye on this is because the clean energy solutions we choose to invest our time, money and effort into now really matter. Will fusion ever deliver? The jury is still out. Experimental facilities such as JET have shown that the power of stars can be tamed for short periods. In that sense, progress is accelerating. But there are still big challenges, not least finding a material robust enough to house a fusion reaction in the long term.

To truly harness the power of a star on Earth, we have a long way to go, but the recent advances are reasons for optimism. As countries across Europe struggle to keep the lights on this winter (see page 12), we are reminded that any alternative to fossil fuels is worth exploring. ▮

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Small scale
The most precise measurement of a particle ever **p9**

Vaccine inequality
Covid-19 jab rates for children in England vary by ethnicity **p11**

Heaviest bony fish
A southern sunfish weighs in at 2744 kilograms **p14**

Methane leak
Nord Stream breach released over 50,000 tonnes of gas **p19**

Nature in peril
Wildlife populations in dramatic decline, warns WWF **p23**

GEORGE CLERK/GETTY IMAGES

Chicken farms have been told to step up their biosecurity

Animal health

Bird flu runs rife in the UK

Officials announce new biosecurity measures across the country as it prepares for its worst ever outbreak, reports **Madeleine Cuff**

THE UK is bracing itself for what is expected to be the worst outbreak of avian flu in its history this winter, with officials warning of a rapid rise in infections over the past month.

Infections are six weeks ahead of where they were this time last year, according to the Animal and Plant Health Agency (APHA). There are 47 ongoing outbreaks in the UK, 30 of which have been confirmed this month.

In a bid to contain the influenza virus, which spreads through infected droppings, the APHA this week imposed a "prevention zone" across England, Scotland and Wales. The Northern Irish government has also introduced the same policy.

That means UK farmers and amateur bird owners will have to ramp up biosecurity measures, for example by changing their clothes and shoes before entering enclosures, as well as disinfecting vehicles used on site.

But with high levels of infection among wild bird populations, there is growing concern that it may prove impossible to contain the outbreak.

The UK's chief veterinary officer, Christine Middlemiss, said the situation was unprecedented. "We've never had to do this before. We've never had this level of environmental infection going on before that's posing such a risk," she told the BBC.

Cases of avian flu have appeared periodically in the UK for decades, but there have been a record number of outbreaks in the past 12 months, caused by a highly pathogenic H5N1 strain of the influenza virus.

> "There's an awful lot more virus out there. We haven't had a break over the summer"

Around 3.5 million captive birds have been culled since October 2021, while the virus has ripped through wild populations, hitting the UK's globally recognised seabird colonies particularly hard.

Usually, the summer months bring respite, but this year was different. New outbreaks were recorded throughout June, July and August for the first time.

"There's an awful lot more virus out there than we've had in previous years," said Andy Paterson at the APHA in a press briefing. "We've certainly not had a break over the summer like we would normally expect."

It means the UK is heading into the winter and the next migratory season with higher levels of the virus circulating, officials warn. Over the next few weeks, millions of ducks, swans, geese and other migrating birds will arrive to winter in the UK, which will amplify the threat.

The H5N1 virus was first detected in Guangdong province in southern China in 1996 and has since spread globally via infected wild birds. Scientists suspect the current outbreak – which has also wreaked havoc across continental Europe and the US – could be down to a slight mutation in the virus that means it can survive for longer periods in the natural environment, allowing it to spread through wild bird populations more effectively.

There is little officials can do to control the spread of the virus among wild birds. Instead, containment efforts are focused on keeping captive birds isolated from wild populations. That is becoming harder in the face of climate change, with last winter's storm damage and floodwaters helping to spread infected droppings into captive flocks.

If the biosecurity measures imposed this week fail to curb the number of new outbreaks, the next step will be a nationwide housing order, which would mean that all captive birds must be kept inside until further notice. ▮

Archaeology

Neanderthal family values

Analysis of DNA from a cave in Siberia has provided insights into the way our prehistoric relatives lived, reports **Michael Le Page**

ANCIENT DNA from a group of Neanderthals who lived together has given us an unprecedented glimpse of the social structure of these extinct human relatives. Among other things, it suggests that the women moved between groups while the men stayed put.

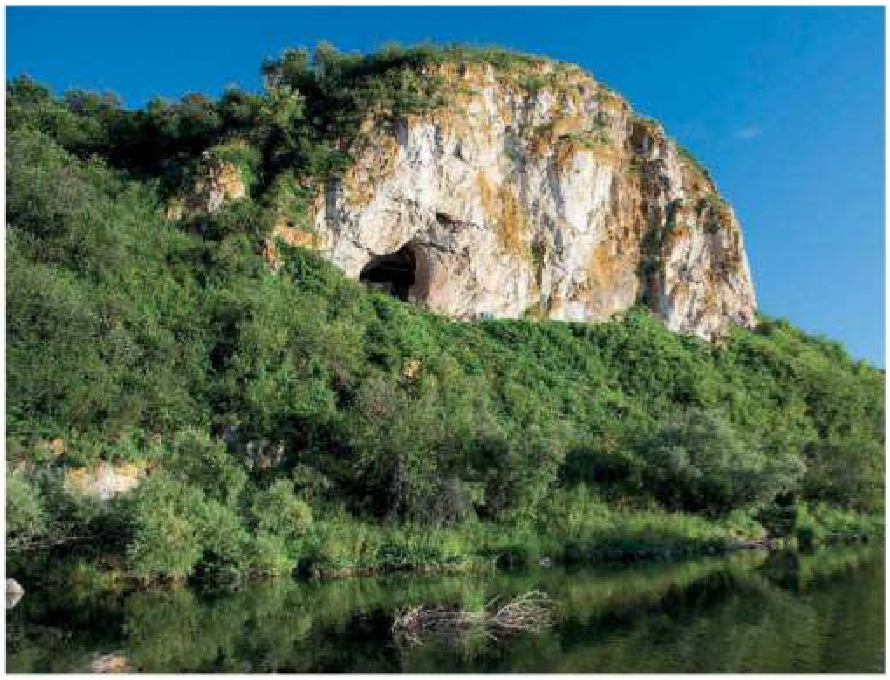
Researchers have previously tried to work out what the social organisation of Neanderthal groups was like from evidence such as the layout of caves and footprints, says Benjamin Peter at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, but the DNA provides direct evidence. "It's the first time we've been able to do something like this using genetics," he says.

To work out social links, Peter and his colleagues managed to extract DNA from 15 out of 17 pieces of Neanderthal bone or teeth recovered from the Chagyrskaya cave in the Altai mountains in Siberia, Russia. The DNA showed that some pieces came from the same individuals, so the findings represent 11 people in total, including several teenagers and children.

"The level of inbreeding is comparable only to species that are critically endangered, like gorillas"

Dating of sediments and bison bones at the site suggests the Neanderthals lived in the cave sometime between 59,000 and 51,000 years ago, while the DNA shows that many of them were related. "We can say that they very likely lived at the same time," says Peter.

For instance, there is a father and daughter among the remains. The father also shares mitochondrial DNA, inherited from the mother, with two other men, meaning they had a common female ancestor, such as the same grandmother.


SKOV ET AL.

The entrance to Chagyrskaya cave in Siberia, Russia

Another man and woman are second-degree relatives, meaning the woman might be, say, the grandmother or aunt of the man. The team doesn't have enough of their genetic material to determine the precise relationship.

The DNA also reveals a very high level of inbreeding, much higher than in modern hunter-gatherer groups, suggesting a very small population in the area. "It's very unusual," says Peter. "The only thing we've found that is comparable are species that are critically endangered, like gorillas."

However, the team can't say whether this high level of inbreeding affected the health of these individuals. It may be a result of being an isolated group on the edge of the range of Neanderthals, rather than being true of Neanderthals generally.

"Other Neanderthal sites like Vindija [in Croatia] indicate larger and more diverse populations," says Chris Stringer at the Natural History Museum in London, who wasn't part of the Chagyrskaya research team.

The researchers also compared the diversity of Y chromosomes, inherited from the father, with that of mitochondrial DNA. They found an order of magnitude more mitochondrial diversity, says Peter. "I don't know any human population where we would see that," he says. This suggests that men stayed in group in which they were born and that most women moved to different groups (*Nature*, DOI: 10.1038/s41586-022-05283-y).

Female-based migration is the predominant pattern in modern hunter-gatherers, says Stringer, and there is some evidence for it among Neanderthals from the El Sidrón site in northern Spain. "So finding this at another site, with more data, does suggest that this was a common pattern in Neanderthals," he says. ▮

Ecology

Empires left legacy on global spread of non-native plants

Luke Taylor

EUROPEAN occupation and trade in the colonial era irreversibly transformed the global distribution of plants, leaving a legacy that can still be seen today.

The expansion of European empires from the 15th century onwards is known to have spread plant species around the world – for example, the common dandelion (*Taraxacum officinale*) was spread widely across the British Empire.

To quantify the impact that colonisation had on the distribution of plants, Bernd Lenzner at the University of Vienna in Austria and his colleagues studied records of non-native species in 1183 regions of the former British, Dutch, Portuguese and Spanish empires in a global database.

The time that regions colonised by the same empire spent as colonies was as strong a predictor that they would share the same non-native species as modern social and economic factors were. "The impact is almost equally important to the trade that we observe nowadays, so it's really a strong signal still in this composition of flora," says Lenzner.

The strongest predictors that countries would share the same types of non-native plants were proximity, common temperature and aridity, as climates dictate where alien species can survive.

But for non-natural causes, the time a country spent in the British or Spanish empires had more of an impact than GDP or human population density (*Nature Ecology & Evolution*, doi.org/jg4f).

The global spread of alien species was partly driven by the export of crops for agriculture in colonies, such as millet in the British Empire and sweet potato in the Portuguese Empire. But a fascination with exotic plants in the 18th and 19th centuries also played a key role, says Lenzner. ▮

Health

Transplanted livers can function for a total of over 100 years

Carissa Wong

LIVERS transplanted from older donors can last a century in total and sometimes outlive ones from younger people.

Transplanting livers from older donors after they die is generally avoided because livers tend to accumulate more scarring over time, caused by factors such as drinking alcohol, obesity and viral infections. Now, researchers have provided evidence that transplants from older donors can work very well.

Christine Hwang and Yash Kadakia at the University of Texas Southwestern Medical Center and their colleagues analysed data on 253,406 liver transplants from deceased donors that occurred in the US between 1990 and 2022.

The team found that 25 livers had lasted for at least 100 years across both the donors' and recipients' lifetimes, with 14 still remaining in their recipients. The oldest liver was aged 108. "We do not know of any other types of organ transplants that have lasted 100 years," says Hwang.

All livers that eventually reached the age of 100 lasted for at least a decade in the recipient, while 60 per cent of livers that didn't reach 100 lasted for a decade after transplantation, the team told the American College of Surgeons Clinical Congress in San Diego, California, on 16 October.

People who donated livers that reached the age of 100 were aged 84 when they died, on average, while those who donated livers that failed to survive for 100 years had an average age of 38 when they passed away. This provides evidence that older donors can sometimes contribute more successful liver transplants than younger ones.

Livers suitable for transplantation are in short supply

BSIP SA / ALAMY

By analysing blood sample data collected from donors soon after they died, the team found that donors of livers that survived for a century had a lower level of blood enzymes called transaminases – associated with inflammation and liver injury – than people who donated livers that didn't make it to 100.

Using a mathematical model that aids transplant decisions in the clinic, the team found that livers that made it to 100 lasted longer than expected based on a variety of donor and transplant recipient factors, such as the presence of other diseases, age, sex, ethnicity and body mass index.

This suggests the model may not account for key unknown factors that determine how long livers last. It isn't known if the findings would apply to liver transplants that take place outside the US.

"Studying these livers that made it to age 100 could reveal new biomarkers that are important for liver lifespan," says Kadakia. "Manipulating such markers in livers before transplantation could help us improve the outcome."

"It is important that this study shows that good quality donor livers that are older can go on to do very well in their new recipients," says Patricia Lalor at the University of Birmingham, UK. "We need as many donor organs as possible to address increasing requirements for transplantation." ▮

Physics

Most precise measurement of a particle ever made

A NEW assessment of the electron is the most accurate measurement of a particle we have, at a precision of 1.3 parts in 10 trillion.

The electron's magnetic moment is a quantum property related to magnetism and is predicted by the standard model, our current understanding of how the basic building blocks of the universe interact. But the standard model is unable to explain certain real-world observations, so researchers are seeking discrepancies between predicted and measured properties of fundamental particles as a way to look for new physics.

Gerald Gabrielse at Northwestern University in Illinois and his team have measured the electron's magnetic moment 2.2 times more precisely than before, finding it in agreement with the previous best measurement, in 2008.

To do this, they trapped a single electron in a chamber with an ultra-stable magnetic and electric field, isolated from any external forces and cooled to just above absolute zero, and then measured the electron's response as they changed the magnetic field (arxiv.org/abs/2209.13084).

While this new measurement agrees with the standard model, as the old one did, it can't be used to fully test the model because its predictions are actually less precise than the measurement. This is because the standard model relies on a number called the fine structure constant, a measure of the strength of electromagnetism between particles. Physicists can't quite agree on the size of this constant, with two groups finding significantly different values for it.

1.3

Precision of the measurement of the electron, in parts per 10 trillion

With a more precise and accurate fine structure constant, it should be possible to properly compare the new electron magnetic moment value with that predicted by the standard model. If at that point there is a discrepancy between the two, then new physics will be needed to explain it, such as a new structure for the electron. ▮

Alex Wilkins

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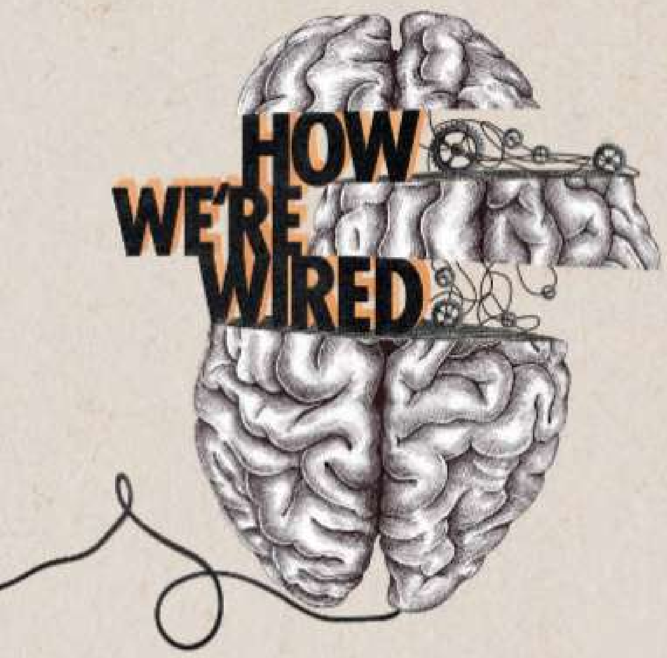

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Covid-19

Childhood vaccine uptake in England varies with ethnicity

Jason Arunn Murugesu

COVID-19 vaccination rates among children in England vary between certain ethnic groups, according to Office for National Statistics (ONS) data.

ONS researchers analysed covid-19 vaccination rates among children aged 12 to 15 who go to state-funded schools in England – equivalent figures aren't available for the rest of the UK. As of 22 July, 62.4 per cent had received at least one dose of the Pfizer/BioNTech vaccine, the only coronavirus vaccine approved for people under 18 in the UK. Just 45.3 per cent of 12 to 15-year-olds had received at least two doses, the maximum number offered to children in this age group.

Uptake was lowest among those from Gypsy or Roma ethnic groups, with 15.8 per cent receiving at least one dose. This was followed by children from Black Caribbean ethnic groups, at 16.5 per cent.

Children from Chinese and Indian ethnic groups were the most likely to have received at least one dose, at 83.5 per cent and 75.7 per cent respectively.

In England, all children aged 12 to 15 have been offered two Pfizer/BioNTech vaccine doses.

The ONS figures also reveal that children from more deprived areas are less likely to be vaccinated than those from more well-off areas. Up to 22 July, 44.8 per cent of 12 to 15-year-olds from the most deprived areas had received at least one dose of a coronavirus vaccine, compared with 80.7 per cent of those from the least deprived areas.

15.8%

of children from Gypsy or Roma ethnic groups are vaccinated

"In terms of the inequalities, it's not really surprising that people in deprived areas and ethnic minorities are getting less care than others," says Michael Absoud at King's College London. "That's been the history of health."

Vaccination rates among children aged 5 to 11 also vary among different ethnicities. ONS figures aren't available for this group, but statistics from family doctors show that vaccination rates in this age bracket in England peak in children of a South Asian background, with 12 per cent receiving one dose by 10 August.

According to Stephen Griffin at the University of Leeds, UK, not enough is being done to encourage covid-19 vaccinations among children. "They protect against severe disease and they also protect to an extent against long covid," he says.

Griffin worries that the UK government is sending the message that it is fine for children to catch the coronavirus multiple times.

The risk of severe disease with covid-19 is far lower in children than adults, but if large numbers of children catch the virus this winter, a substantial proportion will develop severe symptoms, according to Griffin.

The next coronavirus variant could be more dangerous for children, he says.

Two Pfizer/BioNTech doses provide some protection against disease caused by the omicron variant.

A Department of Health and Social Care spokesperson told *New Scientist*: "We have provided advice and information on covid vaccines to parents at every opportunity, including through TV, radio, social media and letters from schools, translated into 13 languages. The offer remains open for parents to get their children vaccinated to increase protection as we live with this virus." ▮

UK children are offered up to two doses of covid-19 vaccine

FLY VIEW PRODUCTIONS/GETTY IMAGES

See page 16 for an interview with the former head of the UK Vaccine Taskforce

Animals

Female robins are just as skilful at singing as males

Christa Lesté-Lasserre

FEMALE European robins (*Erithacus rubecula*) sing throughout autumn and winter – and their songs are just as physically and mentally challenging as those of males.

Outside the breeding season, when food and hiding places are scarce, both sexes sing equally difficult songs as a way to mark the limits of their individual territories.

A female robin whose songs were analysed in the study

JULIE BOSCA

"One of the motivations behind this study was to get females heard in studies on bird songs because, for a long time, researchers were focusing only on males and thought that whenever a bird was singing, it must be a male," says Nicole Geberzahn at Paris Nanterre University in France.

For their study, Geberzahn and her colleagues recorded the regular territory-marking songs of 22 European robins, half of which were female, from October to December. The researchers analysed an average of nearly 12 songs per bird, all sung spontaneously – meaning they weren't responding aggressively to another bird approaching their territory.

Both males and females produced very complex songs with the same kinds of frequency variation, with similar extremes and switches within comparable gaps of time. The researchers used this information to calculate a vocal performance score for each bird. Male and female robins had similar scores, showing their songs had similar muscular, neurological and respiratory demands (*Animal Behaviour*, doi.org/jg25). ▮

Energy

Can Europe avoid blackouts?

The energy crisis will reach a crunch point as winter begins in Europe, with governments hoping they can cut consumption fast, as **Carissa Wong** reports

AS EUROPE braces for winter, its nations are aiming to reduce their electricity use in the hope of avoiding blackouts as energy prices soar and temperatures drop. But how easily might countries cut consumption, and will they succeed in doing so?

On 30 September, European Union energy ministers agreed to try to reduce electricity use between 1 November and the end of March by 10 per cent, based on average usage in the past five years (excluding 2020 due to the effects of the coronavirus pandemic).

According to an analysis by energy research group Aurora of the 14 EU countries for which data was available (see "Powering down", opposite), the Netherlands had already exceeded the target in August this year, using 14 per cent less electricity compared with the country's average for the same month. This was more than double the 6 per cent average August electricity usage reduction across all 14 nations.

CHRISTIAN ENDER/GETTY IMAGES

German cities like Berlin will turn lights off early on public monuments

The Netherlands's success was partly due to fertiliser factories and oil refineries curtailing energy-intensive operations in response to high fuel prices, which are "the best signal to use less energy", says Ryan Alexander, European power market analyst at Aurora.

Following the Netherlands, Greece saw the second highest electricity demand reduction, of 12 per cent, in August. This is probably because people are more sensitive to energy prices in Greece compared with other EU countries, as their energy prices are higher than the EU average while wages are lower. The Greek summer also wasn't as hot as average, which lowered air conditioning demands.

A key help for the Netherlands may have been an energy-saving campaign called "Flip the Switch" that began in April, focusing on turning off lights, swapping filament light bulbs for energy-efficient LED ones, limiting hot showers to 5 minutes and turning heating thermostats in buildings down to 19°C (66°F).

> "The challenge is providing incentives to save power while also shielding people from high prices"

Surveys indicate the campaign has raised awareness of ways to cut gas and electricity use, said energy advisor for the Netherlands Lucas Boehlé at an EU energy-saving workshop on 28 September. Similar measures have been adopted in Spain, Italy, France and Germany, where lights are also being switched off early in shops and public monuments.

Spain saw an 8 per cent reduction in electricity demand in August, suggesting its energy-saving campaign is working. Neighbouring Portugal, which shares a gas price cap with Spain, only launched similar measures in September and saw just a 3 per cent reduction in August.

France on alert

While it is currently impossible to assess the precise energy-saving impacts of each behavioural policy, there are messaging lessons to learn from the early days of the coronavirus pandemic, says Alexander. "Countries should be aiming for the level of publicity we had with covid case numbers."

In that vein, France has rolled out a national alert system, broadcast on TV after weather bulletins. This "Ecowatt forecast" labels the next four days green, amber or red depending on the expected strain on the electricity

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system. People can also sign up to receive alerts by email or text. “That’s a model which has some promise if it could be rolled out to other [EU] member states as well,” says Alexander.

“If it’s an average winter, Europe’s going to be fine. But prolonged cold spells could be tricky”

In August, before Ecowatt appeared on TV screens, France saw a 5 per cent cut in electricity consumption, lagging behind the EU-wide average. This may partly be due to its government capping electricity price rises to 4 per cent this year. “The challenge for policy-makers is providing incentives for households and businesses to save power and gas while at the same time shielding them from the high prices,” says Alexander.

Poland, Denmark and Germany are among the countries that will need to do more heavy lifting to hit EU targets, according to the analysis, having seen the lowest energy reductions, of between 2 to 5 per cent, this August.

Poland may especially struggle to reach EU energy-saving targets due to its high reliance on cheap coal, which made up 69 per cent of its electricity mix in 2020, reducing the impact of high gas prices.

One reason Denmark and Germany’s electricity reduction in August fell short of the EU average is that they have more energy-efficient power plants that capture the heat produced alongside electricity generation, says Alexander. This lessens price pressures and hence incentives to cut use, as these plants use less fuel to output the same energy, compared with plants that lose more energy through heat loss.

“Countries’ performance in August on this measure will not necessarily imply the same results from November or December onwards,” says Alexander. “But one key takeaway [from these figures] is that price signals alone have already managed to reduce demand significantly across member states.”

Paul Ekins at University College London says he would be “amazed if countries fail to reach EU targets, simply because of the high prices”. He also thinks the weather is the single biggest factor influencing the risk of winter energy shortages. “If it’s an average or warmer-than-average winter, I think Europe’s going to be fine. If we have very prolonged cold spells, then obviously things could be tricky.”

Unlike the EU, the UK government hasn’t committed to energy-reduction targets. It has also previously refused to launch an energy-saving behavioural campaign, but on 12 October, UK prime minister Liz Truss said the government was “working on a plan to help companies and individuals use energy more efficiently”. Further details of the project have yet to be released, despite National Grid ESO – which operates the electricity grid in England, Scotland and Wales – recently warning of potential 3-hour blackouts this winter.

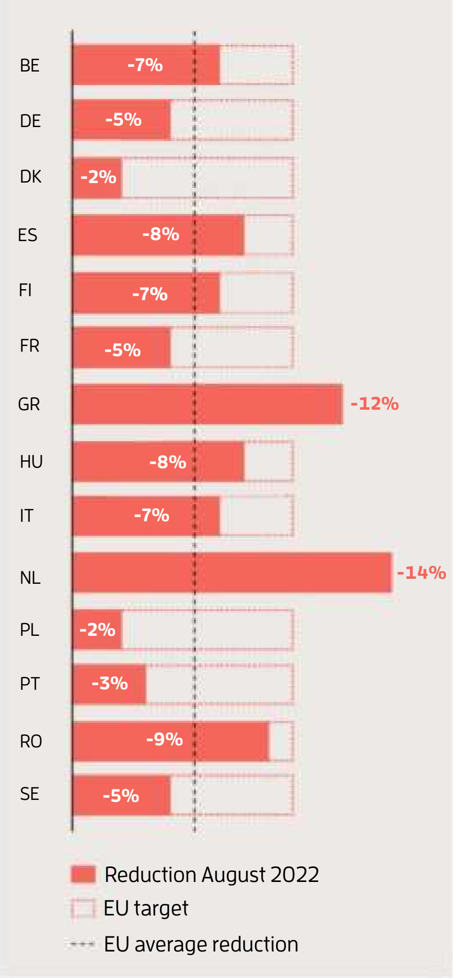
“It’s extraordinary to me that the UK government hasn’t gotten an information campaign and indeed has not set up an energy-efficiency advice service with a few hotlines that people can call and that could give people decent advice,” says Ekins.

Failing to seize the chance to educate the public about energy reduction could also have long-term implications. All governments already needed to cut consumption to meet climate change targets, and a new zeal for energy efficiency could be a benefit to come out of the crisis.

“In the longer term, I must say, I’m pretty positive,” says Ekins. While carbon emissions are likely to rise in the short term as nations make more use of coal-fired power stations, energy reduction campaigns may ultimately speed cuts this decade. “Obviously, Europe is a relatively small part of global emissions, but I think that, potentially for Europe, this could be positive for our 2030 emission targets rather than the reverse.”

Powering down

Europe’s energy savings



SOURCE: AURORA

Residents are being urged to switch to low-energy lighting in some EU nations

CHRISTINE_KOHLER/GETTY IMAGES

Unique opportunity

There is only so much that can be achieved by asking people to switch devices off, however. Ultimately, reducing emissions will also require measures such as electrifying transport and industrial processes and installing better building insulation and heat pumps. It will also rely on countries making sure they move away from gas infrastructure that has been newly built to deal with the current crisis, says Ekins. “There’s a danger we keep using gas for longer than we would have. We need to avoid this.”

Alexander is also hopeful that increased deployment of renewables before 2030 could help counteract shorter-term increases in carbon emissions that will occur over the next few years.

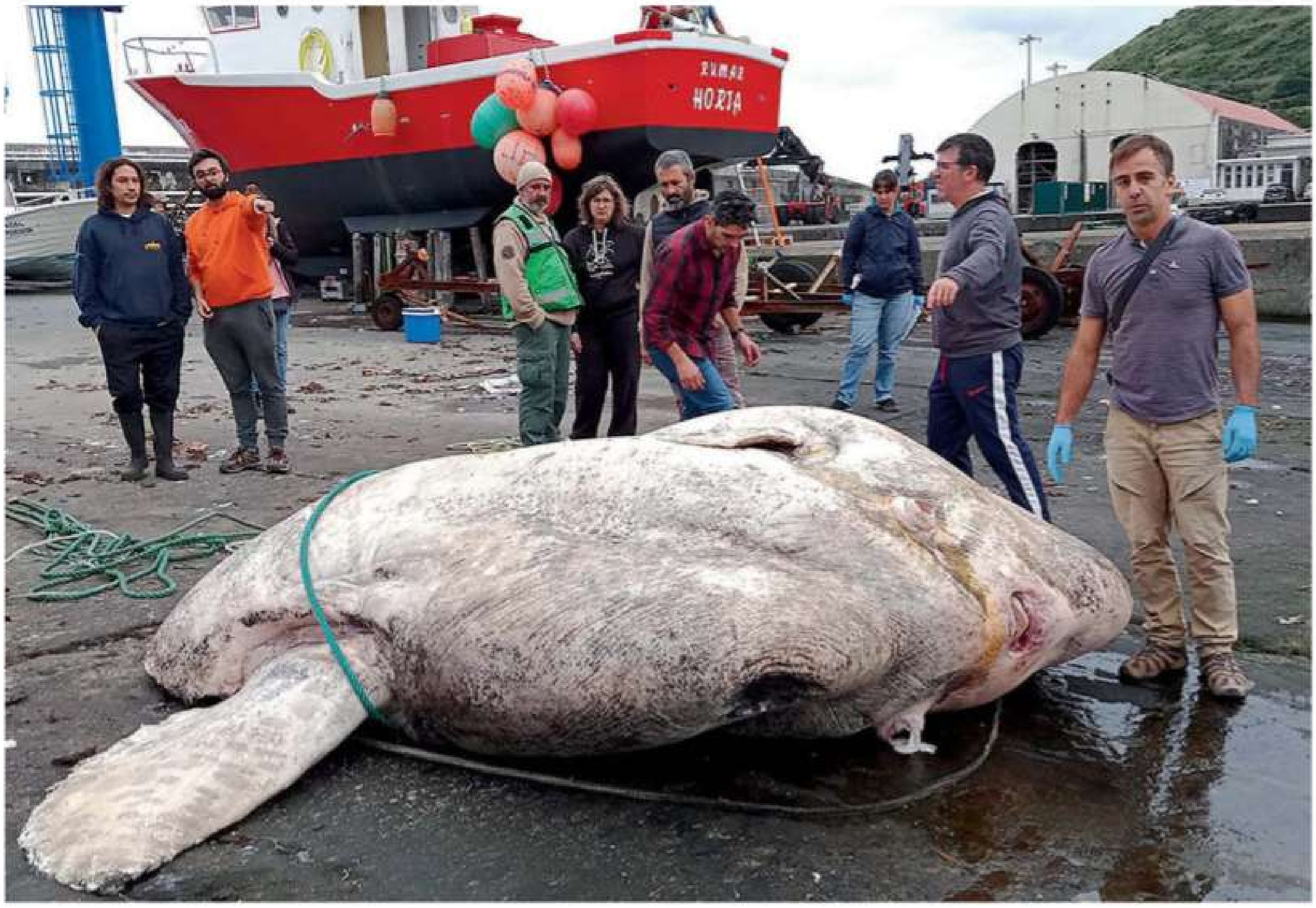
Once gas prices fall, Ekins thinks governments will have a unique opportunity to enforce carbon taxes to help reduce consumption of carbon-based energy, as people will have become more used to the idea of paying a premium for gas. “This would be an amazing opportunity to really cut our gas consumption in the medium and long-term,” he says. ■

Animals

Giant of the seas

Although it was found dead, there is a new heaviest bony fish

Alex Wilkins



ATLANTICNATURALIST.ORG

A SOUTHERN SUNFISH (*Mola alexandrini*) discovered near the Azores in the Atlantic has taken the record for the world's heaviest bony fish, at 2744 kilograms.

Although there are heavier fish without bones – like the cartilage-filled whale shark (*Rhincodon typus*), which can weigh more than 20 tonnes – the previous record holder for the world's heaviest bony fish was a southern sunfish found in Japan in 1996. It weighed 2300 kg and was 272 centimetres long.

In December 2021, José Nuno Gomes-Pereira at the Atlantic Naturalist Association in Portugal and his colleagues found a dead sunfish floating off the coast of Faial Island in the Azores. They managed to pull the carcass to shore and, using a crane, weighed it at 2744 kg – more than 400 kg heavier than the previous heaviest. It was 325 cm in length (*Journal of Fish Biology*, doi.org/jgr7).

Space

Neutron stars' jet seems to break cosmic limit

A JET of radiation from two colliding neutron stars appears to be travelling at seven times the speed of light, according to measurements from the Hubble Space Telescope. Although this is merely an optical illusion, as nothing can travel faster than the speed of light, it provides key insights into mysterious gamma ray bursts, which aren't fully understood.

In 2017, astronomers at the Laser Interferometer Gravitational-Wave Observatory detected a wave, GW170817, produced from the collision of two neutron stars. This was followed up by dozens of Earth and space-based telescopes, which then captured a bright flash of light and powerful gamma rays – an incredibly fast jet called a gamma ray burst.

The initial measurements from this network of telescopes, which used a technique called Very Long Baseline Interferometry (VLBI), found that the jet was travelling at least 95 per cent the speed of light and traced its rough direction of travel. But given the 130 million light years between Earth and the neutron stars, along with the relative dimness of the gamma ray burst, there were still many uncertainties about the jet.

Now, Kunal Mooley at the California Institute of Technology and his colleagues have compared the VLBI data with measurements from the Hubble Space Telescope taken eight and then 159 days after the collision, to achieve a much higher level of precision than previous measurements (*Nature*, doi.org/jg2v).

The team found that the jet seems to be moving seven times faster than the speed of light, but this is an optical illusion caused by the fact that the light is pointing towards Earth in our planet's direction of travel. A similar effect happens if you point a laser beam at the moon and sweep it across the surface – the dot of the laser appears to move faster than light, even though no individual photons do.

7

The jet's apparent speed in multiples of the speed of light

However, the highly precise measurement does tell us important things about the jet's real speed, at 99.97 per cent the speed of light, and its direction of travel, as well as give a much more precise handle on its location, in a small region of the shell galaxy NGC 4993. "Now, what we can do is really zoom in much further, 1000 or 10,000 times further, into this event and find out what the local properties of this event are," says Mooley. **AW**

Health

Menstrual cycles vary among different ethnic groups

Sara Novak

A PERSON'S ethnicity may influence the length of their menstrual cycle. This cycle is a series of physiological changes that prepare the body for pregnancy. Part of it is a period, when a person bleeds from the vagina, which commonly occurs every 21 to 40 days.

To better understand how menstrual cycles can vary, researchers led by a team at the Harvard T.H. Chan School of Public Health collected data on 12,608 people via a tracking app. The volunteers were recruited based on whether they had periods, not their gender identity.

The results show the cycles were, on average, 1.6 days longer in the participants who identified as Asian and 0.7 days longer in those who identified as Hispanic, compared with their white, non-Hispanic counterparts (medRxiv, doi.org/jg3r).

Cycle variability was also 9 per cent and 10 per cent higher in the participants who identified as Asian or Hispanic, respectively. The researchers found no meaningful menstrual cycle variabilities between people of the other ethnicities they analysed.

It is unclear exactly why menstrual cycles vary between people of different ethnicities. "Some possible factors may include systemic racial disparity, e.g. inequity in socioeconomic status, access to healthcare and exposure to the environment, such as endocrine-disrupting chemicals in personal care products," says lead author Huichu Li.

Previous research suggests that shorter menstrual cycles may be linked to breast cancer, while longer cycles have been associated with an increased risk of premature death. The latest study didn't investigate whether these risks apply to people of different ethnic groups, says Li.

Technology

Mind-reading AI decodes thoughts from brain scans

Alex Wilkins

AN ARTIFICIAL intelligence can detect when someone is thinking about specific concepts such as food or sleep just by looking at brain scans. The system might one day be used to help people who have lost the ability to speak or to investigate mental health conditions.

When we receive a stimulus from the outside world, such as hearing words or seeing an image, this is encoded in the brain as neural activity. Attempts to decode this activity to work out what words might have caused a specific neural signal have had mixed results, and the most successful tend to require invasive, surgically implanted electrodes.

Now, Alexander Huth at the University of Texas at Austin and his colleagues have developed a machine learning-driven AI model that can work out word sequences that match, or resemble, the input stimulus from people's brain activity and the meaning behind them.

First, Huth and his team recorded functional MRI (fMRI) data for three brain networks associated with language processing: the prefrontal network, the classical language network and the parietal-temporal-occipital association network. This was done as a small group of people listened to 16 hours of narrated stories to train the model to understand and predict how someone's brain would respond to a particular sequence of words.

The researchers then asked participants to listen to a new story so the model could try to decode the corresponding brain recording, and compared the words from the story with the decoded version.

While the precise words in each version differed, metrics comparing the meanings of passages found that the model's results were significantly better than they would have been by chance alone.

Huth and his colleagues also tested the decoder on people telling imagined stories and watching short silent films, and managed to extract similar-meaning words and sequences for both (bioRxiv, doi.org/jgsd).

Here is one example of story text: "that night i went upstairs to what had been our bedroom and not knowing what else to do i turned out the lights and lay down on the floor".

The AI translated the resulting brain patterns as: "we got back to my dorm room i had no idea where my bed was i just assumed i would sleep on it but instead i lay down on the floor".

"The fact that the decoder can get the gist of the sentences is very impressive," says Anna Ivanova at the Massachusetts Institute of Technology. "We can see, however, that it still has a long way to go. The model guesses bits and pieces of meaning and then tries to put them together, but the overall message typically gets lost – likely because the captured brain signals reflect what concepts a person is thinking about, such as 'talk' or 'food' for example, but not how these concepts are related."

Brain scans contain information that an AI can read

YUICHIRO CHINO/GETTY IMAGES

The model also seems better at predicting concrete words, such as food, than abstract terms, adds Ivanova.

There are two components to improving decoding models, says Jack Gallant at the University of California, Berkeley: better brain scans and more powerful models. While fMRI capability hasn't progressed much in the past decade, computational power and language models have.

"The fact that the decoder can get the gist of the sentences is very impressive"

"This work dials the computational model up to 11," says Gallant. "This is really the innovation that is most responsible for producing such great results."

As well as potentially being able to help people who can't speak to communicate, this advance could be used to investigate mental health conditions, says Gallant.

Although there are privacy concerns about accessing thoughts, Huth and his team say that these aren't currently problems because the model requires so much training data and cooperation.

"If you didn't listen to several hours of podcasts while lying in an MRI machine, Huth and his colleagues probably can't decode your thoughts – at least not yet," says Ivanova.

Health

UK unprepared for next pandemic

Kate Bingham, former head of the UK's Vaccine Taskforce, says the government hasn't done enough to get ready for future disease threats, reports **Clare Wilson**

THE UK has missed key opportunities to prepare for the next pandemic, says Kate Bingham, the former head of the country's Vaccine Taskforce.

The government is no longer steering vaccine research and development to prioritise new technologies that could be strategically vital. It has also missed chances to maximise manufacturing capacity in the UK, she tells *New Scientist*.

"We definitely have more capacity now than we used to," says Bingham. But she still brands the current facilities "inadequate".

The former "vaccine tsar" makes the criticisms in her new book, *The Long Shot: The inside story of the race to vaccinate Britain*. In May 2020, Bingham took an unpaid, seven-month break from her work as a biotech venture capitalist to oversee the fastest possible development and purchase of millions of doses of covid-19 vaccines.

Initially, the odds of getting a vaccine before most people caught the coronavirus were thought to be low. But the Pfizer/BioNTech covid-19 vaccine was being injected into arms in the UK by December 2020, with the Oxford/AstraZeneca version arriving the next month. The UK was the first in the world to deliver both these outside clinical trials and the task force had signed contracts for mass supplies as some other countries scrambled for doses.

The fast rollout of jabs to older and vulnerable people as the alpha wave of the coronavirus crashed through the UK in early 2021 saved thousands of lives, according to calculations by Public Health England.

STEVEN MAY/ALAMY

Kate Bingham oversaw the UK's covid-19 vaccine programme

But as well as securing vaccines against covid-19, the task force was also charged with building permanent pandemic resilience in the UK. "We did not achieve this," says Bingham in her book.

The UK continues to fund basic medical research that could lead to more potent coronavirus vaccines, or jabs against the next pandemic pathogen, she says. But there is little central oversight or strategic planning, and it can be hard for academics to get funding through the usual mechanisms of government grants, she says.

"There's no coordination. We are losing oversight of the next technologies that we should be thinking about. So it's back to where we were before, which is: 'You can apply for a grant'."

The UK does at least have more vaccine manufacturing capacity than before the pandemic struck, including at a facility that made fish vaccines in Essex, bought by a government agency. US firm Moderna has also said it aims to start producing vaccine at a big research and manufacturing site for mRNA jabs in the UK by 2025.

But Bingham says it was wrong for the UK to pull out of a deal to buy 100 million doses of covid-19 vaccine from the French firm Valneva last year – a decision that looked baffling one month later when positive final-stage clinical trial results were announced.

Valneva's vaccine works in a different way to the other products used in the UK and the cancellation led to the loss of planned jobs at the firm's factory in Scotland. If the deal had gone ahead, it would have diversified the UK's vaccine capabilities and been helpful for supply to low-income countries, says Bingham.

She is also concerned about the UK's decision to sell the Vaccine Manufacturing and Innovation Centre, which helped develop the Oxford/AstraZeneca jab, to the US firm Catalent, as it is unclear if the government has negotiated the right to commandeer the plant for national use in pandemics. The government hasn't released details of the contract and declined to answer *New Scientist*'s questions about it. Nor did it answer other questions about pandemic preparedness.

> **"We are losing oversight of the next technologies that we should be thinking about"**

Another issue for Bingham is a U-turn on plans to make the UK more appealing as a place to run clinical trials. In 2020, more than half a million people volunteered for coronavirus vaccine trials via a National Health Service website, with more than a third aged over 60 – a group that is often hard to recruit and yet is most needed.

On signing up, people were asked if they could also be contacted about non-covid-19 trials, with 94 per cent saying yes. But the government-funded National Institute for Health and Care Research (NIHR) has since said that, as the scheme is widened to other disease areas, everyone must reapply. A spokesperson for the NIHR says: "We are reviewing how to share information about opportunities to take part in a wide range of other health research with everyone on the registry who would like to receive it."

Bingham says the process of reapplying is too cumbersome and will see the number on the register fall. "This is a massive shooting themselves in the foot. They will never create that again," she says. ▮

SOLARSEVEN/GETTY IMAGES

Covid-19 vaccines have saved thousands of lives in the UK

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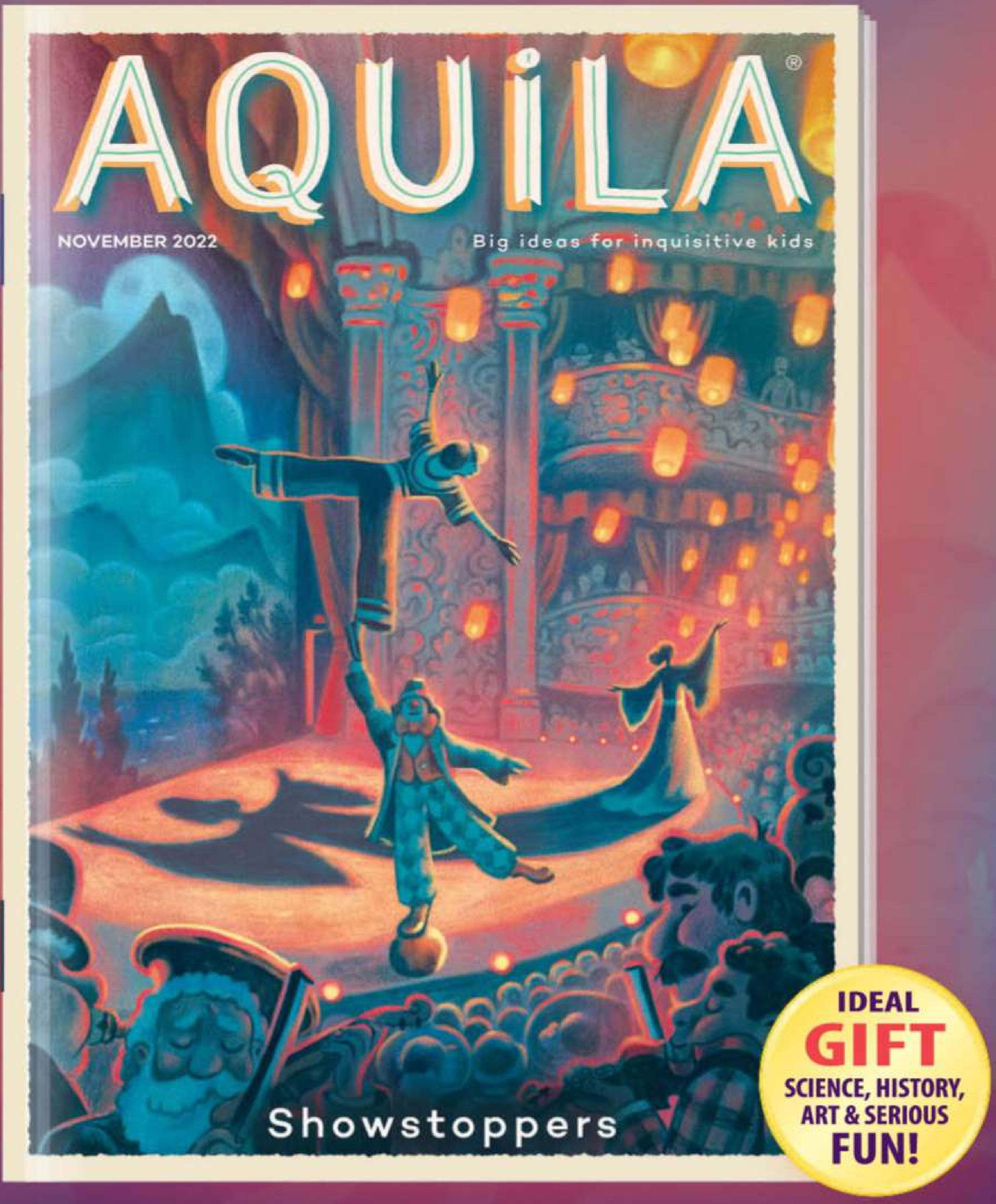
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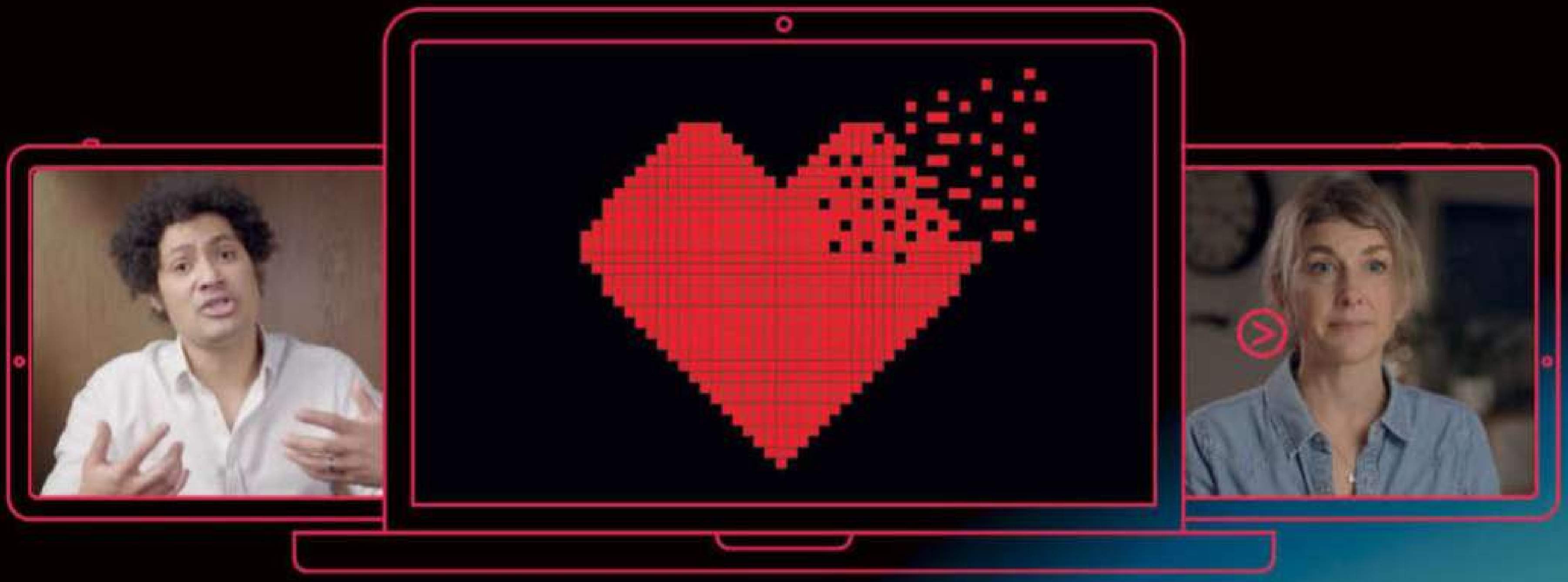

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Environment

Nord Stream leak may be largest ever

First measurements of pipeline leak show it may be the biggest methane emission seen

James Dinnean

THE Nord Stream pipeline leak was responsible for what is probably the largest single methane emission ever recorded, according to new measurements.

The Nord Stream 1 and 2 pipeline systems were built to bring natural gas from Russia to Europe beneath the Baltic Sea. On 27 September, large blasts punched holes in three of the pipes in what government leaders around the world have called an act of sabotage. Natural gas, which is mostly made of the potent greenhouse gas methane, immediately started bubbling up through the water and into the atmosphere.

As of 2 October, all three pipes had run out of gas and stopped leaking, according to the Danish Energy Agency. Satellite observations on 3 October didn't detect any methane at the surface.

To quantify the size of the leak, Rona Thompson at the Norwegian Institute for Air Research and her colleagues used measurements from a network of ground-based monitoring stations in Finland, Norway and Sweden called the Integrated Carbon Observation System (ICOS).

Soon after the leak began, ICOS stations detected large spikes in methane as the plume swirled hundreds of kilometres away from the pipeline breach. Satellites also made some measurements of the leak, but their view was mostly obscured by clouds.

The researchers modelled how wind carried methane away from the leak, as well as the rate of methane emission from the pipeline based on where the leak occurred in each pipe. They assumed the rate decreased once the shorter sections of pipeline had emptied out, says Stephen Platt, also at the Norwegian Institute for Air Research.

Methane from the Nord Stream leak bubbling up in the Baltic Sea

DANISH DEFENCE

They found that the pipeline emitted between 56,000 and 155,000 tonnes of methane, depending on the method they used to relate the data to their atmospheric model. The estimate is the first based on actual measurements of the leak and is significantly less than previous estimates. The Danish Energy Agency's worst-case estimate of how much methane would be released based on the amount of gas thought to be in the pipeline was about 500,000 tonnes.

The disparity could be because some methane remained in the pipeline or dissipated in the water, says Thompson. "I don't think all the gas that was in the pipeline reached the atmosphere," she says. There are also uncertainties in their atmospheric models, which have limited resolution for emissions from a single point. "It's a blurry image," she says.

155,000

Tonnes of methane that may have leaked from Nord Stream pipes

Still, Thompson says the Nord Stream leak was "quite likely" the largest ever methane emission from a single point. The largest previous such emission released about 100,000 tonnes of methane in California in 2015.

While massive for a single event, the latest emission is roughly equivalent to what the oil and gas industry emits every two or three days, says Manfredi Caltagirone at the UN Environment Programme's International Methane Emissions Observatory. ▮

Health

Gel made from okra stops bleeding in damaged hearts

A STICKY gel made from okra stops bleeding in the injured organs of dogs and rabbits. This biodegradable substance could potentially be used in humans if it is shown to be safe and effective.

Bleeding from punctured organs is often stemmed with sutures, but this may cause inflammation and people can die before sutures can be sewn. As a result, surgeons sometimes use gels made from the protein fibrin to rapidly halt bleeding, but they are expensive and derived from animals.

Now, Malcolm Xing at the University of Manitoba in Canada and his colleagues have created a freeze-dried powder from okra juice that forms a gel after contact with blood and rapidly seals injury sites.

When the team used the powder to seal roughly 1-centimetre-wide circular wounds in the hearts and livers of dogs and rabbits, bleeding stopped within 1 minute. Substantial bleeding occurred in wounds that weren't treated with the gel (*Advanced Healthcare Materials*, doi.org/jgnt).

"Though we only monitored the wounds for 2 minutes after applying the gel, without the adhesive, it would typically take up to 20 minutes for clotting to occur in such wounds," says Xing. By then, the animal or patient may be dead.

"The gel itself forms a physical barrier, but also initiates the blood clotting process"

"There are two components, the gel itself forms a physical barrier, but also, it initiates the blood-clotting process," says Xing.

Further experiments hinted that the gel dissolves harmlessly in the body after four to seven weeks.

The gel is about one-hundredth of the price of similar fibrin-based adhesives, says Xing, and the team hopes to test it in humans in roughly three to five years. ▮

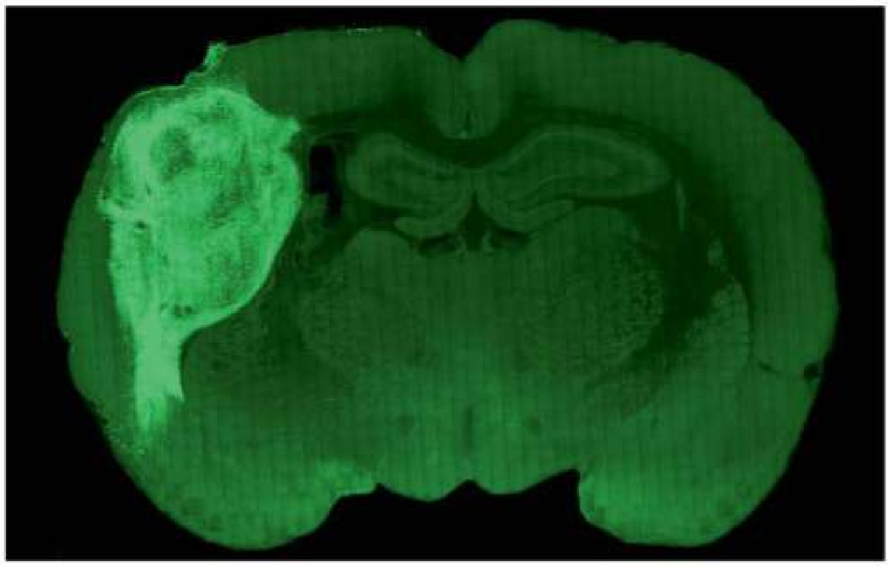
Carissa Wong

Neuroscience

Human neurons transplanted into young rats' brains

Jason Arunn Murugesu

HUMAN neurons have been transplanted into the developing brains of young rats for the first time, demonstrating a technique that could be used to test new psychiatric drugs.



STANFORD UNIVERSITY

Human tissue tagged with a fluorescent protein in a rat brain

In the past decade, researchers have developed mini models of the brain called organoids, made by growing stem cells into three-dimensional structures in the lab. They can be used to study the effects of drugs on human cells, but even the most complex brain organoids lack the intricacy of real neurons in the brain.

By transplanting human organoids into a rodent brain, researchers can manipulate the cells and see how this affects the animal's behaviour, says Sergiu Paşca at Stanford University in California.

Researchers have previously carried out this type of transplant in adult rats, but Paşca and his colleagues have now transplanted human brain organoids into rats that were just a few days old. By targeting the rats when their brains were still developing, the researchers hoped that the human neurons would be better integrated into the organs. The rats all had dysfunctional immune systems to ensure that the human cells wouldn't be rejected.

"The human neurons grew to fill around a third of one hemisphere of each rat's brain"

The human neurons became far more mature and about six times larger than they would have been had they developed in a dish. They grew to fill around a third of one hemisphere of each rat's brain and formed connections known as synapses with rat neurons.

To see if the human neurons could influence the rats' behaviour, the researchers used a technique called optogenetics, which involves genetically altering cells so that they respond to light.

They gave the rats water each time they shone blue light onto the human neurons in the rat brains. After about two weeks, the rats started licking in expectation of water when the team shone blue light on these neurons (*Nature*, doi.org/jgpc).

Paşca says this new model can overcome some of the limitations of using organoids in drug testing. As many psychiatric conditions are behaviourally defined, it is hard to link the activity of human brain cells in a Petri dish with a behaviour associated with a condition. By implanting organoids into rats, researchers can study human cells and see how interventions affect animals' actions.

"This current study by Paşca's group has taken [research on brain organoid transplantation] to the next level by using several state-of-the-art technologies," says Guo-li Ming at the University of Pennsylvania. "Not only did they show long-term growth – up to eight months – and maturation after transplantation, but also synaptic integration and contribution to the behaviour of those human cells."

"This research will expand various neurological research [in areas] such as neurodevelopmental disorders, neuropsychiatric disorders, substance use disorders, neurogenerative disorders and many other diseases that are known to disrupt brain circuits," says Julia TCW at Boston University.

However, many will question the ethics of an approach that combines human and animal brains. "It seems to me that rats' consciousness as it is, without human manipulation, is rather remarkable and that damaging a rat's brain is emblematic of an attitude towards nature that imperils human and non-human animals' prospects for continued life on Earth," says Taimie Bryant, a professor of animal law at the University of California, Los Angeles. ▮

Animal cognition

Black widows can remember their prey when it is stolen

Corryn Wetzel

SOME web-building spiders can form memories of the prey they catch, and this rare ability has now been seen in black widows.

Clint Sergi, who was at the University of Wisconsin at the time of the work, and his colleagues collected 69 female wild western black widow spiders (*Latrodectus hesperus*) in Oregon and allowed them to build webs in enclosures in the lab. They then dropped crickets – a tasty treat for a black widow – onto some of the webs, and waited for the spiders to wrap them up in silk and then retreat.

"Right when they started walking back, we'd steal the cricket from them," says Sergi. The spiders began searching around their enclosures for the lost meal within seconds. They spent between 30 seconds and 22 minutes, with an average of 10 minutes, searching for their lost prey (*Ethology*, doi.org/jgpq).

Spiders that received the biggest crickets looked longer, on average, than those who had smaller meals pilfered – but only if those crickets were in the vertical part of the web, called the gumfooted lines. Large crickets caught in gumfooted lines elicited longer search times than smaller crickets, but when prey was snagged in the canopy-like web, spiders showed less interest overall. This suggests that black widows can recall details of the size of their prey and where it was caught in their web. ▮

A female western black widow spider (*Latrodectus hesperus*) in Arizona

JOHN CANCALOSI / NATUREPL.COM

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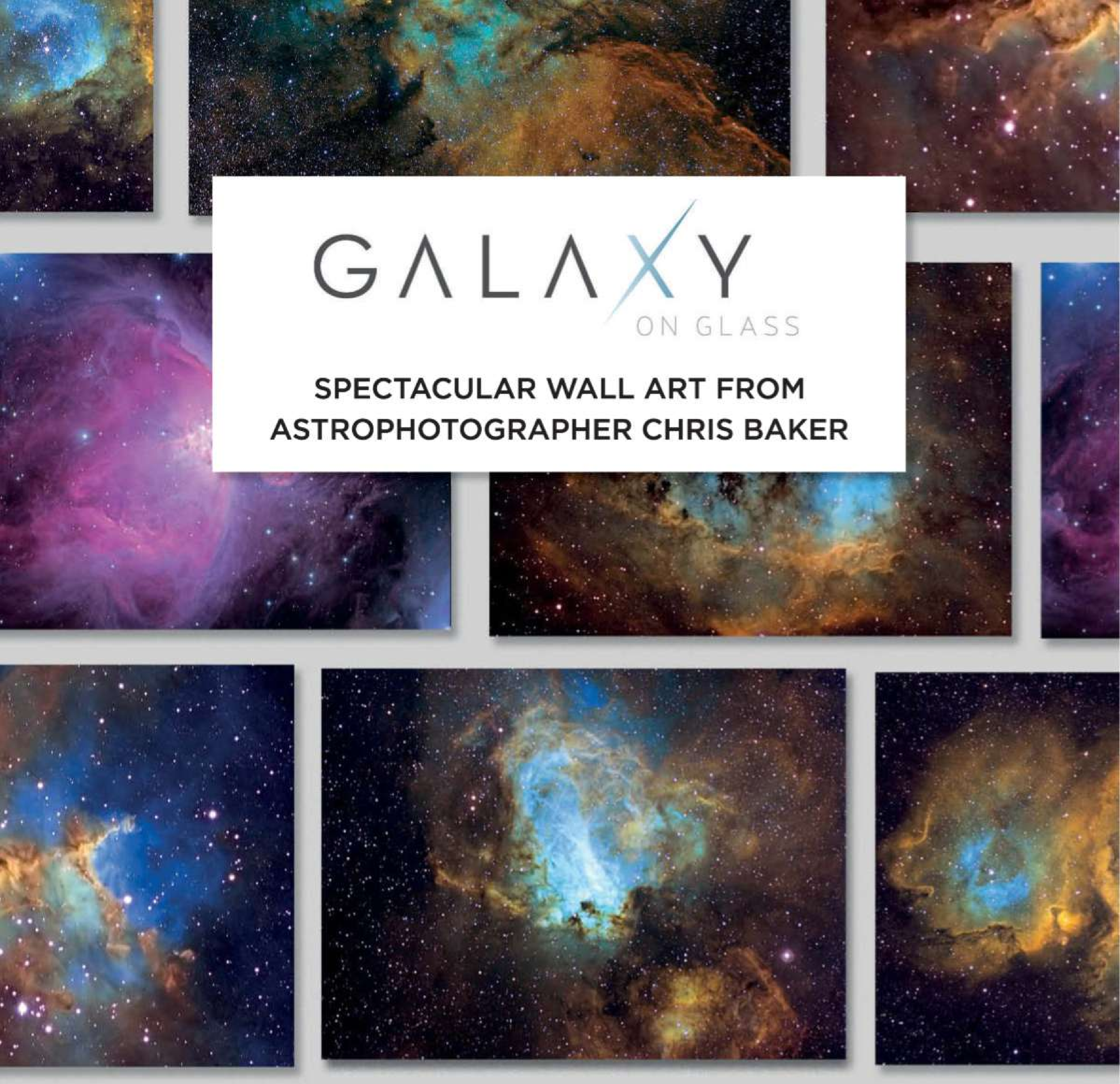

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Biodiversity

Wildlife populations are declining on a 'devastating' scale, says WWF

Madeleine Cuff

WILDLIFE populations around the world are facing dramatic declines, according to new figures that have prompted environmental campaigners to call for urgent action to rescue the natural world.

The 2022 Living Planet Index (LPI), produced by the Zoological Society of London (ZSL), reveals that studied populations of mammals, birds, amphibians, reptiles and fish have seen an average decline of 69 per cent since 1970, faster than previous predictions. It tracked global biodiversity between 1970 and 2018, based on the monitoring of 31,821 populations of 5230 vertebrate species.

Mark Wright of WWF says the scale of decline is "devastating" and continues to worsen. "We are not seeing any really positive signs that we are beginning to bend the curve of nature," he says.

Freshwater vertebrates have been among the hardest hit populations, with monitored populations showing an average decline of 83 per cent since 1970. The Amazon pink river dolphin (*Inia geoffrensis*), for example, has seen a 65 per cent decline in its population between 1994 and 2016.

Habitat loss and degradation is the largest driver of wildlife loss in all regions of the planet, followed by the overexploitation of species through hunting, fishing or poaching.

In December, governments from around the world will gather in Montreal, Canada, for the COP15 Biodiversity Framework, a much-delayed summit that aims to agree a set of new targets intended to halt the loss of animals, plants and habitats globally by 2030.

The Amazon pink river dolphin has seen a 65 per cent decline

PARALAXIS/SHUTTERSTOCK

"This is a once in a decade opportunity," says Robin Freeman of ZSL. He says it is vital that governments use the summit to agree "meaningful, well measurable targets and goals".

"We need governments to have concerted action to ensure that those goals deal with the complicated, combined threats of climate change and biodiversity, in order for us to see meaningful action," says Freeman.

But some researchers are critical of the LPI's use of a headline figure of decline, warning it is vulnerable to misinterpretation. The findings don't mean all species or populations worldwide are in decline. In fact, about half show a stable or increasing trend, and half show a declining trend.

"Distilling the state of the world's biodiversity to a single figure – or even a few figures – is incredibly difficult," says Hannah Ritchie at Our World in Data. "It definitely fails to give us an accurate understanding of what the problem is and how we move forward."

"I think a more appropriate and useful way to look at it is to focus on specific species or populations," says Ritchie.

But Wright says the LPI is a useful tool that reflects the findings of other biodiversity metrics, such as the IUCN Red List and the Biodiversity Intactness Index. "All of those indices, they all scream that there is something going really very badly wrong," says Wright. ▮

Physics

Wobbling black holes prove Albert Einstein right

A PAIR of black holes have been seen wobbling at a rate of three times per second as they merged, in an extreme example of a prediction made by Albert Einstein's general theory of relativity that has been seen clearly for the first time.

This wobbling, known as precession, occurs when the orbit or rotation of an object slowly changes with time. Gravity-induced orbital precession, a consequence of general relativity's prediction that heavy objects bend space-time, sees the shape of such an object's orbit alter over time.

This effect had been observed very weakly in neutron stars orbiting one another, but was so subtle that the orbits only wobbled, or precessed, at a rate of a few times a year.

Now, Mark Hannam at Cardiff University, UK, and his colleagues have seen a much more extreme effect in a pair of black holes moving at a fifth of the speed of light, caused by one of them spinning at a 90-degree angle to its orbital motion.

As they merged, the black holes released a gravitational wave, known as GW200129, that carried the signature of precession at a rate of three times a second (*Nature*, doi.org/jgrq).

"It's 10 billion times faster than what was found in earlier measurements, so it really is the most extreme regime of Einstein's theory where space and time are warped and distorted in completely crazy ways," says Hannam.

"It's 10 billion times faster than what was found in earlier measurements, so it really is extreme"

To identify the precession, the team reanalysed data first collected in 2020 by three gravitational wave detectors, based in the US and Italy. A previous analysis was inconclusive, but using a more advanced model of the gravitational wave signal, Hannam and his team found that the best way to explain the signal was with one of the black holes spinning at almost the upper limit allowed by general relativity, causing the orbit of the system to precess. ▮

Alex Wilkins

Technology

Robot boot helps you walk faster

AN EXOSKELETON boot that lets you up your pace using less energy could help older people or those with disabilities move around.

Existing exoskeletons aren't effective without lengthy fine-tuning in a lab to a person's gait. Now, Steve Collins at Stanford University in California and his colleagues have come up with a computer model that absorbs the data from 3600 of their previous laboratory tests to avoid this.

Their boots can hit the ground running and a wearer can fine-tune them while walking outside, rather than on a lab treadmill. This method got within 5 per cent of the efficiency of the lab approach.

The boots increased walking speed by 9 per cent and cut energy use by 17 per cent compared with normal shoes (*Nature*, doi.org/gqz8k7). **Matthew Sparkes**

Wildlife

Penguin's first egg is always doomed

MEMBERS of a little-known species of penguin always reject the first egg they lay, possibly because they only have enough food to rear one chick and their second egg has a survival edge.

In 1998, Lloyd Davis at the University of Otago in New Zealand and two of his colleagues spent six weeks studying erect-crested penguins (*Eudyptes sclateri*) on Antipodes Island, a rugged, windswept island located 860 kilometres from New Zealand.

The team found that female erect-crested penguins lay two very different-sized eggs about five days apart – the second 85 per cent heavier than the first. The first egg never hatches because it is ignored or pushed away. The second, however, is carefully incubated by the female and usually results in a chick (*PLoS One*, doi.org/gqz79r). **Alice Klein**

GEOFF SMITH / ALAMY

Genetics

Differences in height linked to multitude of DNA variants

A STUDY of 5.4 million people has revealed that over 12,000 genetic variants have an influence on height differences among those with European ancestry. The findings could deepen our understanding of medical conditions affecting growth.

Loic Yengo at the University of Queensland in Australia and his colleagues used a computational analysis to compare the height and genomes of these people, 75 per cent of whom had mainly European ancestry. The team collected data from previous studies or from the DNA testing company 23andMe.

This revealed 12,111 common genetic variants – each found in more than 1 per cent of the population – that could explain 40 per cent of height differences among people with European ancestry. Each genetic variant was a single nucleotide polymorphism, where the specific DNA base at a position in the genome varies across a population.

"Of the remaining 60 per cent in height variation, 40 per cent is [thought to be] from less common genetic variants [that occur in less than 1 per cent of the population] and 20 per cent is from the environment," says Yengo, which means due to external factors such as poor nutrition.

The team also found that the common variants associated with height made up about 20 per cent of the genome and were clustered in regions linked to medical conditions affecting skeletal growth. However, the variants in the study could only explain about 10 per cent of the height differences in those with East Asian, Hispanic, African and South Asian ancestry (*Nature*, doi.org/gqz8jh). Carissa Wong

Really brief

ESO/M. KORNMESSER

Alien worlds have oddly heavy skies

Two massive planets beyond our solar system – WASP-76b and WASP-121b – have the metal barium floating high in their atmospheres. This is the heaviest element ever spotted in an exoplanet atmosphere, and we don't know how it got there (*Astronomy & Astrophysics*, doi.org/gq2hhc).

Preserved dino covered in slashes

The mummified remains of a 7-metre-long duck-billed hadrosaur found at the Hell Creek Formation in North America show gashes and punctures. The dinosaur lived 70 million years ago. Its injuries may have been made by crocodile-like teeth and a large carnivore, such as a *T. rex* (*PLoS One*, doi.org/gqz79s).

Heated car batteries would charge fast

A lithium-ion battery containing tiny heaters that warm it up fast and safely can charge to 70 per cent in just 11 minutes. This would allow an electric vehicle with a big enough version of this battery to go about 320 kilometres and could enable EVs to be "refuelled" nearly as fast as petrol ones (*Nature*, doi.org/gq2gd8).

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Comment

Another sort of gold

Faced with the destruction of the living world, we need a new kind of treasure. It is there, if we could agree to see it, says **Katherine Rundell**

SIMONE ROTELLA

IN 1930, John Maynard Keynes wrote a prediction for the future. By 2030, he prophesied in his essay "Economic possibilities for our grandchildren", technological advance will have largely displaced human labour, leaving the standard of living so high as to free us to discover, for the first time, ways to live well. Then, "the love of money as a possession... will be recognised for what it is, a somewhat disgusting morbidity". It would be seen as a "semicriminal, semi-pathological" propensity.

It is only, Keynes said, when the accumulation of wealth is no longer the central impulse of humanity that we would uncover in ourselves what has lain dormant.

"We shall be able to rid ourselves of many of the pseudo-moral principles which have hag-ridden us for two hundred years, by which we have exalted some of the most distasteful of human qualities into the position of the highest virtues," he wrote.

He was no oracle, Keynes: he was too optimistic about us. But he was right that a dramatic recalibration will be needed, a decoupling of desire and conspicuous consumption. It may be impossible; history so far makes it appear so. But we live under an inescapable imperative: faced with our own swift destruction of the living world, we will have to find a new kind of treasure.

Such treasure does abound, if we could agree at a vast, global, political level to see it. The world is full of living gold. There is, for instance, the jewel scarab beetle, which looks like the work of a gifted artisan. It is thought to use its gold for camouflage, as sunlight casting off its iridescent back may be dazzling to predators – its beauty literally blinding.

The gold of a golden snub-nosed monkey's fur is a more orange shade, bright against its sky-blue face. These are profoundly social animals, forming troops of up to 600, which would be a sight worth giving a great deal for: 600 golden streaks moving in tandem across treetops. Their gold is thought to aid in mating rituals – as part of their sexual dimorphism, the males' golden hairs are more luxuriantly plentiful.

There is the gold, too, of the golden-rumped elephant shrew, which shines boldly in the rear quarters. Red-capped robin-chats have evolved a symbiotic relationship with the shrew, following their golden behinds through forests, eating the detritus of invertebrates they leave in their wake as they forage.

All of these creatures are gold for a reason. But the golden mole is blind. It is also the only truly iridescent mammal. Its fur, in changing light, can shift from yellow to gold to red. Its eyes are covered with a layer of skin and fur, and it has never seen its own radiance. It lives almost entirely underground, emerging only to hunt for insects.

Scientists believe that the fur evolved to be densely flattened, hard-wearing and low-friction to make burrowing easier. The iridescence is an accidental by-product. So the moles burrow and breed and hunt, live and die under the African sun, unknowingly glowing.

To be in the presence of golden animals has a stark, Keynesian effect. They make other forms of gold – watches, bejeweled necklaces, cufflinks, taps – look like a con. We haven't, historically, been talented at identifying what is and isn't treasure. But it is possible that, as Keynes hoped, this isn't inevitable.

What is the goldest gold? It is every living thing. The greatest treasure in the known history of the universe – the world we stand on – is at stake. It requires your disobedience – urgent and iron-willed, political and social – to those interested parties that would tell you to look away and acquiesce in its destruction. ▮

Katherine Rundell's book *The Golden Mole and Other Living Treasure* is out now

Wild Wild Life

Pumpkin to talk about Squashes have an intriguing evolutionary history, eaten in the wild by now-extinct megafauna and first domesticated 10,000 years ago, finds **Penny Sarchet**

Penny Sarchet is *New Scientist*'s news and digital director. She is a former plant scientist and a lifelong birdwatcher. You can sign up to her free monthly newsletter at newscientist.com/wildwildlife

Penny's week

What I'm reading

The Gardener and the Carpenter, *developmental psychologist Alison Gopnik's critique of modern parenting approaches*

What I'm watching

I didn't think there was any aspect of penguin life that hadn't already been on TV, but amazingly Frozen Planet II *has shown me I was wrong!*

What I'm working on

I've been on a very deep dive into the plant life of the Cretaceous Period for a forthcoming feature article

This column appears monthly. Up next week: Chanda Prescod-Weinstein

IN PARTS of the world where autumn is underway, squashes are now on the menu, and shops are stocking up on pumpkins for Halloween. I haven't always been a fan of squashes, but the more I have learned about their evolutionary history, the more I have been charmed by how such unlikely and unpromising fruits came to spread worldwide.

There is a beguiling diversity of squashes and pumpkins, and their range of shapes, sizes and colours gives them much aesthetic appeal. But they all belong to one genus – *Cucurbita* – and fall broadly into only six main species or subspecies. The ancestors of these originated in North and Central America, and many of the cultivars (the domesticated plant equivalent of dog breeds) we eat today belong to one species, *Cucurbita pepo*. One of the surprising things about squashes is that such a diverse array of fruits can be produced by such closely related plants – the pumpkin and courgette (zucchini), for example, are the same subspecies of *C. pepo*.

The squashes' ability to exhibit such a variety of forms, and their complex histories, makes it hard to determine their wild ancestors. But we can draw some generalised inferences on what they were like from the 12 wild cucurbits that live in North and Central America today.

The greatest diversity of wild squashes now resides in Mexico, but it is thought that *Cucurbita* probably originated in Central or South America. These wild species tend to have round fruits, up to 8 centimetres in diameter, that are unpleasantly bitter-tasting, with a hard and inedible rind. The purpose of a fruit is to disperse seeds, and the seeds inside squashes and pumpkins are highly nutritious, which poses a question: before humans came along, what could possibly have eaten them?

Several lines of evidence point to megafauna – the large animals, over 1000 kilograms in weight, that once shaped our ecosystems but largely went extinct at the end of the Pleistocene Epoch, around 11,000 years ago. *Cucurbita* seeds have been found in the ancient dung of mastodons – an elephant-like mammal – and it is easy to imagine such animals having no trouble cracking open the tough skins of ancient squashes.

> **"It is possible that *Cucurbita* evolved its bitter flavours to ensure it was eaten and dispersed by large animals"**

What about the wild squashes' bitter taste? It has been suggested that large animals are less bothered by bitter tastes, as they are less likely to eat enough of these molecules to experience their toxic effects. Smaller mammals, on the other hand, tend to be more sensitive to bitter tastes and have more genes to detect them. So it is possible that *Cucurbita* evolved its bitter flavours to ensure it was specifically eaten and dispersed by particularly large animals, which are also thought to have created the habitats in which wild squashes could have thrived. Many of today's wild squashes grow like weeds, requiring recently disturbed ground to gain a foothold. Before human farmers were around to create this environment, the trampling of large beasts might have done the job instead.

But then the big mammals went extinct – probably due to climate change and human activities – and *Cucurbita* seeds found themselves somewhat trapped within their hard, unpalatable fruits. Today, wild cucurbit species are found in fewer places than they once were.

Yet in 2020, an estimated 28 million tonnes of pumpkins, squashes and gourds were produced worldwide. Domestication gave the cucurbits a second act, enabling them to spread across the world and take advantage of humans for dispersing and planting their seeds. We may originally have used squashes only for their nutritious seeds, and perhaps found other uses for them too – one suggestion is that small gourds may have been used as floats for fishing nets. Once we started selectively propagating cucurbits, they lost their bitter toxins and gained larger fruits.

This act of domestication is one of the oldest in the world. Archaeological evidence suggests *C. pepo* was domesticated in Mexico 10,000 years ago, around the same time that a number of plants that are often described as the first crops – such as wheat and barley – were being domesticated in Asia's Fertile Crescent. Then *C. pepo* was independently domesticated a second time, in eastern North America around 5000 years ago. This lineage gave rise to today's scallop and acorn squashes, among others, while the Mexican lineage is the one that includes pumpkins and courgettes.

There are still many gaps in this tale of the pumpkin, but I hope this provides food for thought if you find yourself carving a pumpkin later this month, and inspires you to cook the flesh you scoop out, rather than throwing it in the bin. ▮

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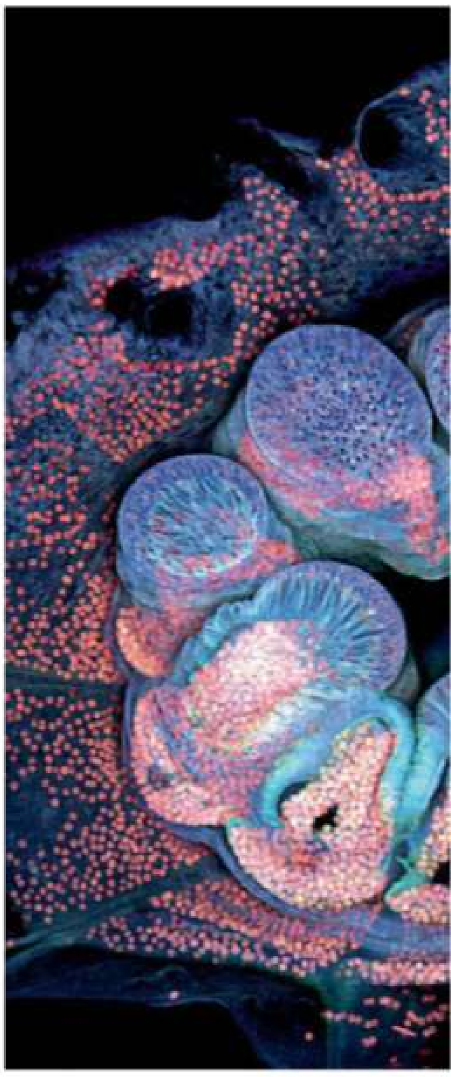
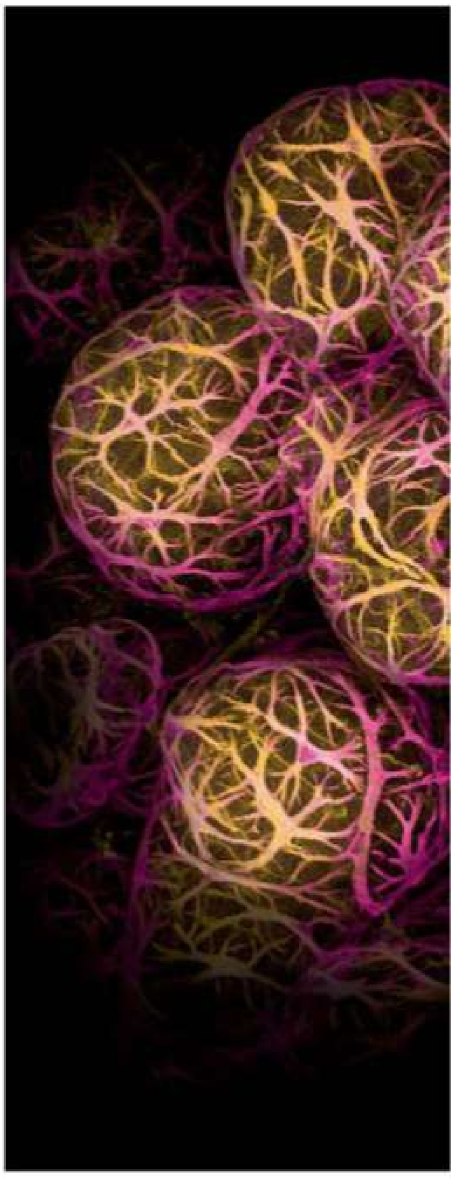
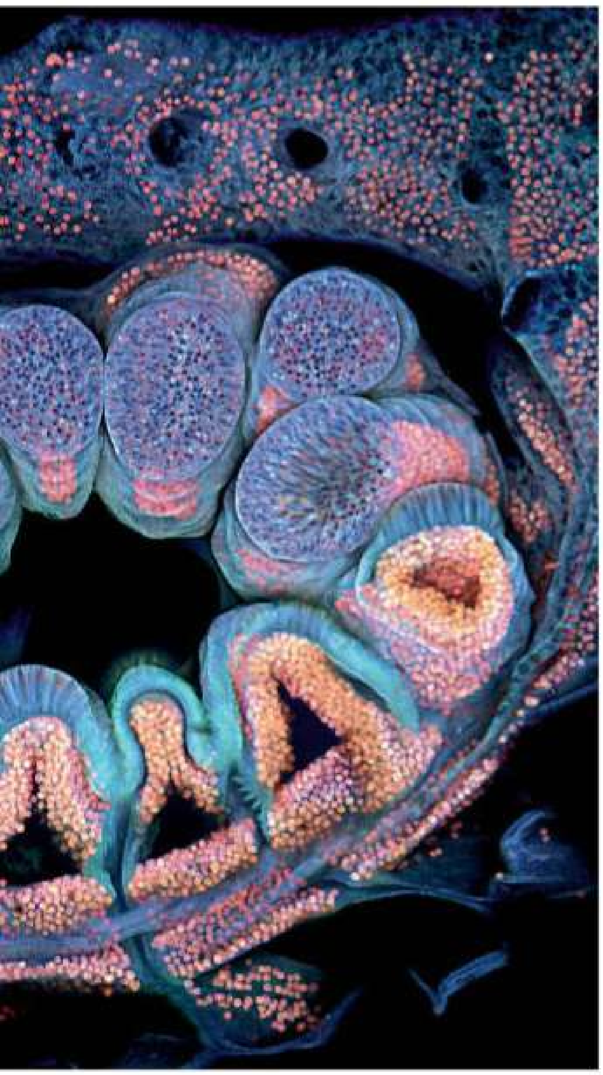
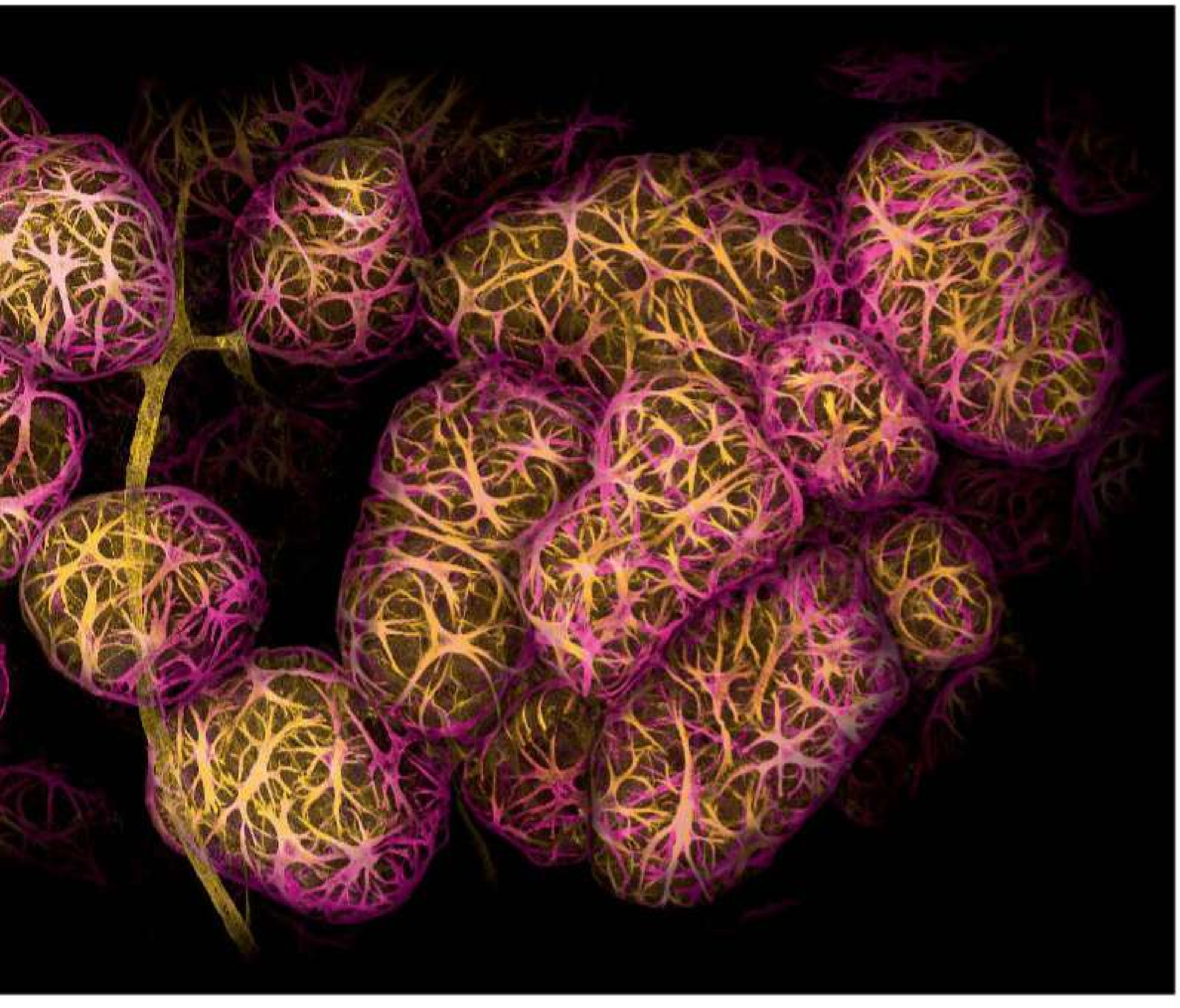




CLOCKWISE FROM LEFT: MURAT ÖZTÜRK; BRETT M. LEWIS; ALISON POLLACK; CALEB DAWSON





On a small scale

Nikon Small World

SITTING at the intersection of microscopy and art, these dazzling images are some of the best entries for the Nikon Small World 2022 Photomicrography competition, a global contest that showcases the beauty of science on the microscale.

A fly is clasped by its eyes under the chin of a tiger beetle in the main image on the left, the 10th place entry taken by Murat Öztürk. But this is no tender embrace. Thanks to their strong jaws and ability to run at up to 8 kilometres per hour, tiger beetles make for formidable predators for their prey, which also include ants, spiders and caterpillars.

At top centre is an image showing the autofluorescence of a 1-millimetre-wide coral polyp, an organism that forms colonies that make up the bulk of a coral reef. Taken by Brett M. Lewis, it came in 12th place. Lewis used the technique of fluorescence imaging, in which high-intensity illumination is used to excite the fluorescent molecules in a sample, to take his shot.

The spherical spore fruiting bodies, or sporangia, of a slime mould from the genus *Lamproderma*, taken by Alison Pollack and placed in fifth, is shown at top right.

At bottom right is the competition's runner-up, taken by Caleb Dawson. It shows myoepithelial cells of breast tissue wrapped around clusters of cells called alveoli that produce breast milk. The myoepithelial cells were stained with fluorescent dyes before being captured with a confocal microscope.

Gege Li

Editor's pick

Yes, psychiatry is in need of a new direction

Leader, 1 October

From Martin Sigrist, Newbury, Berkshire, UK

Your plea to embrace new ways of thinking about mental health conditions caught my attention. As far as I can tell, the methods psychiatry uses today and the theory, or lack thereof, on which they are based don't seem to have changed since the 1980s.

As you pointed out, a central "accepted fact" in this field, the role of serotonin in depression, appears to be in doubt. Is there any other branch of science that has shown such an appalling lack of progress? Is psychiatry even a science? These questions have been asked before and seem to await answers still.

Growth often seems to run counter to climate policies

1 October, p 7

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

Michael Le Page reports on "Alarm at UK growth push", but doesn't mention the area of concern that some would say is of greatest significance, the idea that capitalist growth is incompatible with tackling climate change.

From Steve Blyth, Roade, Northamptonshire, UK

Like many others, I am bemused and alarmed by the lack of action taken by the UK government to mitigate climate change. Is its latest policy emphasis on "growth" going to help? Surely not.

A more realistic approach would be "dynamic stability", in which, as outmoded industries shrink, more eco-friendly ones are encouraged to grow: coal mines are replaced by wind turbines, oil wells by photovoltaic panels, monocultures by diverse land management and so on. This can be nudged in the right direction by regulation and taxation.

Don't get too excited about superluminal messaging

8 October, p 9

From Nick Canning, Coleraine, County Londonderry, UK

Your report of this year's physics Nobel prize asserts the winners showed "information could be instantly transmitted over infinite distances". They didn't. It can still only be transmitted at a maximum speed equal to the speed of light in a vacuum.

What the winners showed was that nature can't be represented by a local-realistic model of the sort Albert Einstein favoured. God plays dice after all, as Niels Bohr believed and as quantum mechanics asserted. This ended the Bohr-Einstein debate over the completeness of quantum mechanics in Bohr's favour.

For a vegan pet, we could opt for herbivores

24 September, p 44

From Moira Nicholson, Corvallis, Oregon, US

"Meat-free mutts and moggies" left me wondering about the environmental impact of making the vitamins, minerals and amino acids needed to supplement vegan pet foods so they meet dogs' and cats' dietary requirements.

Perhaps it is better to pick a pet species that is herbivorous, such as a rabbit, tortoise or parrot. Goats can be housebroken, too. There are plenty of pets that can be eco-friendly without raising hackles over humane treatment.

Peacock feathers are far from wasteful

24 September, p 25

From Guy Cox, Sydney, Australia

In her look at status signals, Solitaire Townsend wrote that Charles Darwin believed "male peacocks' ostentatious feathers prove to females that they are so adept… they can afford to grow big, bright, utterly wasteful plumage". If Darwin really did think this, he can't have spent any real time watching peacocks because those feathers are far from wasteful.

If an unknown or aggressive dog, for example, approaches a peacock, up go those feathers and the dog stops in its tracks. The key factor is the "eyes" on their tails, a common strategy used by animals to startle and repel predators.

What the male means when he displays this to a mate is "look at how capable I am of scaring away enemies and protecting you and our chicks".

Where did all the UK's outdoor pools go?

17 September, p 25

From Sam Edge, Ringwood, Hampshire, UK

I enjoyed Mark Harper's call for Britons to do more outdoor, cold-water swimming.

It is sad that many lidos, once common in the UK, have closed. Compare this with Germany, where municipal *Freibäder* (outdoor pools) are part of the culture and very popular, at least in the summer months, while winter sea swimming is a fairly common pastime in the north.

The Scandinavians go even further, embracing ice-water bathing, often in association with communal saunas. Perhaps this is partly why the Danes, Swedes and Norwegians rank high on measures of happiness, the people of the northern coastal state of Schleswig-Holstein are the happiest in Germany and all are generally healthier than the Brits.

Methane leak is a drop in the global warming ocean

8 October, p 8

From Eric Kvaalen, Les Essarts-le-Roi, France

The estimated 177 million cubic metres of gas that leaked from the Nord Stream 2 pipeline is less than 120,000 tonnes of methane. The effect of that on our climate is negligible in a world where we emit about 30 gigatonnes of carbon dioxide per year.

A more complicated take on the formula for BMI

Letters, 1 October

From Trevor Benn, Bolton, UK

Further to Larry Stoter's idea of changing the formula for body mass index, there are various indices of body build calculated as functions of weight and height. I once suggested weight squared over height cubed would have optimal correlation with obesity as measured by skin-fold thickness, but some colleagues thought this might be too complicated.

Staking claims on the moon may stoke conflict

17 September, p 38

From Paul Broady, Christchurch, New Zealand

There is no need to mine the moon, especially for profit, or to establish bases belonging to individual nations. Both are a recipe for conflict. We should be using our wealth and expertise to solve the many increasing problems here on our wonderful Earth. The moon can be left for 1000 years or more. We might still be here then, especially if we focus fully on the problems of the here and now.

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For the record

It was the effect of the wavelength of blue light that was tested in connection with sleep (10 September, p 12).

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Greta Thunberg has enticed more than 100 experts to write about the climate crisis. No one else could have created this essential resource, says **Rowan Hooper**

Book

The Climate Book

Created by Greta Thunberg

Allen Lane (out 27 October)

IT FEELS like Greta Thunberg has been around for ages – I guess if you are in the fossil fuel business it feels like even longer. Yet it was only in 2018 that she first sat down outside the Swedish parliament and started the School Strike for Climate movement. What has happened since isn't just a testament to her personally – then a bullied teenager with selective mutism, now a globally important figure and icon – but also proof that the change we need to happen can happen. With *The Climate Book*, a stunning and essential new work, she takes her mission to the next level.

Thunberg has used her status to entice more than 100 experts from around the world to write about some aspect of the crisis we face. I can't think of anyone else who would have the clout to do this, and the result is an incredible and moving resource. There are chapters on almost everything you might need to know about, from climate feedback loops to permafrost instability, from tackling consumerism to ecosystem collapse, from managing the transition over to renewable energy to environmental racism, where communities of colour are disproportionately affected by climate change.

The book is divided into five parts: how climate works, how our planet is changing, how it affects us, what we have done about it, and what we must do now. Each section is introduced and rounded off by an essay from Thunberg. What I like about this approach is that it forces each author to distil their expertise into a few pages. Thunberg still gets a pulpit, but the book is a curated, portable library of knowledge, full of classics.

Everyone will get something different from reading this book. The first half covers the science of the unfolding crisis, laying a solid and detailed foundation for the rest of the book to build on. Friederike Otto at Imperial College London explains the science of attribution – determining how we can link heatwaves, droughts and hurricanes to climate change. She reveals the financial cost of extreme weather events that can be attributed to climate change, showing that of the $90 billion of damage done to Houston by Hurricane Harvey in 2017, $67 billion was down to global warming.

In an incredibly powerful (and frankly terrifying) chapter, Johan Rockström, director of the Potsdam Institute for Climate Impact Research, shows the danger of crossing so-called tipping points – processes like ice loss that are irreversible and self-reinforcing – and destabilising the entire Earth system. He writes: "We are determining whether we leave to our children and their children a planet that will continue drifting towards less and less inhabitable states."

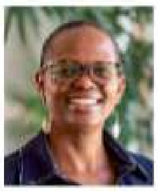
> **"There are chapters on almost everything you might need to know, from climate feedback loops to consumerism"**

In the chapter by Amitav Ghosh, the novelist describes how people in lower-income countries see attempts by those in higher-income nations to impose carbon emissions limits as just another form of colonialism, "a covert means of preserving the economic and geopolitical disparities of the last 200 years". He says it is no surprise that writing on climate change, "which is overwhelmingly produced by western universities and think tanks, is also largely centred on technical and economic issues". (This is a line that hit me, as the author of a book on saving the world called *How to Spend a Trillion Dollars*, quite hard.)

Ghosh says that adequate action on climate change hasn't happened because there is a clash between multinational agencies and the reality of geopolitics, where higher-income countries want to remain dominant over lower-income ones. It is why, as Saleemul Huq, director of the International Centre for Climate Change and Development in Bangladesh, points out, the Intergovernmental Panel on Climate Change is only allowed to use the euphemism "loss and damage" instead of what it means, and what lower-income countries need, "liability and compensation".

There are other reasons for

Expert opinion: Key quotes from some of Greta Thunberg's contributors


UKCOP26.ORG

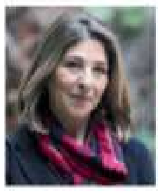
Wanjira Mathai, managing director for Africa at the World Resources Institute

"When women possess land, and the seeds and tools to work it, they possess agency to adapt to climate change."

DALE KAKKAK

Robin Wall Kimmerer, environmental biologist, State University of New York

"Everyone must become a humble student and learn to live as if they were native to place, as if the Earth were One Bowl and One Spoon, to live as if the future were in our hands. Because it is."


ANDREU DALMAU/EPA-EFE/SHUTTERSTOCK

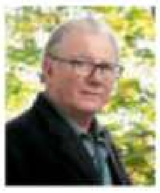
Naomi Klein, author

"The bottomless quest for profits that forces so many to work upwards of fifty hours a week with no security, fuelling an epidemic of isolation and despair, is the same quest for bottomless profits that has pushed our planet into peril."

BRITTANY MURPHY/UC REGENTS

Solomon Hsiang, director of the Global Policy Laboratory at the University of California, Berkeley

"One additional degree of warming does not have the same effect everywhere, and this has profound implications for global inequality."


BEOWULF SHEEHAN

Eugene Linden, journalist and author of *Fire and Flood*

"The message that should lodge with politicians and the public is that climate change must be averted at any price because its ultimate cost can be neither imagined nor calculated."

MAURO UJETTO/NURPHOTO VIA GETTY IMAGES

'Ask yourself, are you prepared to change?' writes Greta Thunberg

inaction, too. The Norwegian psychologist and politician Per Espen Stoknes identifies five, which he calls the 5 Ds: Distancing, Doom, Dissonance, Denial and iDentity. We see climate change as something in the distance, we fear the doom and disaster, which leads to guilt and makes us avoid the issue. We try to justify what we do because of cognitive dissonance between our actions and their effects (carbon emissions), and we deny ourselves understanding so that we can carry on with daily life. And iDentity is the feeling that changes to lifestyle threaten our freedom and sense of self.

Reading this, you are left in no doubt about the scale of the task we face. It isn't "just" the climate crisis, but also the related crises of sustainability and biodiversity, and of equality and justice. All Thunberg's authors make suggestions for what needs to be done for their part of the problem, and Stoknes shows us ways to address and counter the 5 Ds.

In her chapter, economist Kate Raworth lays out her vision on how to escape and recover from consumerism, the driver of economic growth for a century or more. Policy-makers can "edit out" lifestyle options that are unsustainable and "edit in" better alternatives. In France, for example, the government banned short-haul domestic flights, promoting train travel instead.

It is daunting. We might feel that changes to our individual lifestyles are mere drops in the bucket, especially when we learn that the idea of the personal carbon footprint, ostensibly a way we can take responsibility for our greenhouse gas emissions, was dreamed up by BP as an attempt to shift responsibility from profit-chasing Big Oil to us, the consumer. But as we see in the chapter by environmental social scientists Stuart Capstick and Lorraine Whitmarsh, it is vital we make changes, and talk about them. Look at how fast vegan options have become available in restaurants and supermarkets in many countries, for example. "The potential exists for domino effects," Capstick and Whitmarsh write. "Many separate actions can lead to the overturning of social conventions through disruptive and rapidly spreading tipping points." This is the kind of tipping point we need.

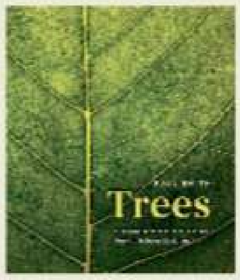
"Instead of asking others if there is still hope," writes Thunberg, "ask yourself, are you prepared to change?" Change creates hope, and hope creates change, she writes – but it needs to be worked at. Thunberg ends with a list of things we could do, starting with treating the crisis as a crisis. As political scientist Erica Chenoweth writes, only massive collective action will embolden decision-makers to take the actions required for climate justice, so that those least responsible for climate change aren't the most affected.

This book is an extraordinary body of work and I can't recommend it highly enough. You feel the passion as well as the intellectual heft of the authors and that is what is so moving about it. It is time for all of us to rise up. ▮

Don't miss

Watch

The Peripheral, a series based on the novel by William Gibson, stars Chloë Grace Moretz (pictured) as Flynne Fisher, a gamer whose VR headset transports her to a future London. Now streaming on Amazon Prime Video.



Read

Trees: From root to leaf are the subject of this lavish compendium by ecologist Paul Smith. Inspiring photographs and infographics explore scientific, cultural and artistic aspects of the 60,000 tree species that inhabit our planet. Available in the UK now.

Visit

Can we trust the statistics in the media? Also, how should you assess numerical claims? David Spiegelhalter poses these questions at Imperial College London and online at 5.30pm BST on 26 October.

TOP: SOPHIE MUTEVELIAN/PRIME VIDEO, BOTTOM: THINGLASS/GETTY IMAGES

The sci-fi column

The trouble with consciousness What is it to be conscious, and why do we simultaneously seek it out and dread it in other entities? Ray Nayler's staggering book has grand ambitions, and even provides a few answers, finds **Sally Adee**

Sally Adee is a technology and science writer based in London. Follow her on Twitter @sally_adee

Book
The Mountain in the Sea
Ray Nayler
MCD Books

Sally also recommends...

Book
Beyond the Burn Line
Paul McAuley
Gollancz
Intelligent moles, or perhaps badgers, that are living in the legacy of an extinct race of intelligent bears must confront their history. Another take on animal consciousness, maybe. Also heavy on philosophy.

GREMLIN/GETTY IMAGES

Why are we drawn to the narrative of AIs rising up to rain judgement on us?

WHAT is consciousness and why are we so obsessed with it? We want to understand it in ourselves, we speculate about – or doubt – its existence in others, we look for it in other species and we are even trying to author our own version of it in artificial intelligence.

Full disclosure: in all my years as a science journalist, I could never quite get my head around the so-called hard problem of consciousness. I could recite the theories, but it wasn't until I read Ray Nayler's *The Mountain in the Sea* that I truly understood it in my bones. This book has many layers. It has the clothes of a futuristic eco-punk or cyberpunk thriller, the guts of a philosophy seminar and the soul of a religious tract.

The thriller: Nayler's book is a speculative science-fiction novel set in a quasi-dystopian future around the Con Dao archipelago off the coast of Vietnam. This area has recently been established as the last sanctuary for the world's marine species after automated fishing vessels – proper sea monsters: murderous, enormous and driven by an internal logic, created by us, with a hunger that can never be sated – have reduced our oceans to biological deserts. These craft still roam the world, as dangerous for humans as they are for the few fish that remain. In the Con Dao protectorate, marine biologist Ha Nguyen and an advanced android intelligence called Evrim work together to study the local octopuses, which may have achieved not only consciousness, but much more besides. Can they understand these creatures before the sea monsters break through?

> **"Automated fishing vessels, murderous and enormous, still roam the oceans they have reduced to deserts"**

The philosophy: With the sole exception of Evrim, the futuristic AIs in Nayler's book are driven by a simplified caricature of human consciousness. And what an indictment they are. Our own human consciousness makes us wired for extraction. "Humans can only do what we are capable of," Nayler's characters repeat more than once. "All we have is taken from someone else," is another refrain. Horrors ensue when the AI mimics turn their eyes on humans to see precisely what we are for, and what we can be put into the service of.

If this sounds like a familiar plot – and it has been an obsession in recent history, from *The Matrix* to *The Terminator* – Nayler quickly turns its conventions upside down and inside out, asking why we are so drawn to the narrative of AIs rising up to rain judgement on us, their creators. He finds the answer not in our fear of AI-borne judgement, but in our longing for it. Deep down, we wish for something else to take over and force us to stop ruining the world. We want to be judged, and to be forgiven. We want someone better than us to be in charge.

The tract: In short, the search to understand human consciousness and the urge to create a silicon version stem from a common root: a tacit admission that there is a flaw in our operating system and that we can't keep going the way we have been. Nayler explores in staggering detail why this means human consciousness needs to evolve beyond separate brains floating in individual vats.

Seven-and-a-half billion of these isolated brain vats have already begun affecting the world as if they were a single mega-entity, and a haphazard and destructive one at that. We already operate as a collective intelligence, so the next step in our evolution must be learning to function as a deliberate and benevolent one. Talk about a hard problem. ▮

New Scientist Debate

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Our ability to develop, manufacture and distribute therapeutics has changed dramatically with covid, Brexit and the increasingly volatile geopolitical landscape. That has created numerous challenges for life sciences companies in the risks they face, in securing supply chains and in managing regulatory affairs. But periods of great change bring opportunities too as new products and approaches emerge and markets evolve.

Join our panel of experts to discuss the forces buffeting the biotech and pharmaceutical industries and the transformational changes that are becoming possible.

CONFIRMED PANELLISTS INCLUDE

Anusha Foy
Head of Life Sciences Biotech Regulatory Solutions Practice, KPMG

Alan Morrison
Vice President of Regulatory Affairs International, MSD

Richard Torbett
CEO, Association of the British Pharmaceutical Industry

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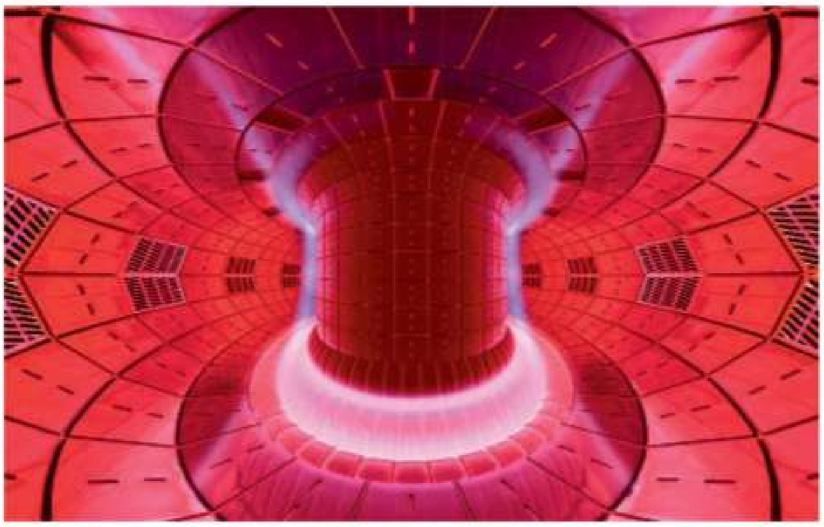

THE NEW AGE OF FUSION

As advances accumulate, firms are promising commercial fusion reactors within a decade. Is there any reason to believe them, asks **Thomas Lewton**

CYRIL ABAD/FUSION FOR ENERGY; DAVID PARKER/SCIENCE PHOTO LIBRARY; EUROFUSION; NORRISPHOTO/TAE TECHNOLOGIES; LUIGI AVANTAGGIATO; GENERAL FUSION

IN MARCH 1951, the president of Argentina, Juan Perón, announced the results of a secretive project on Huemul Island in northern Patagonia. His scientists had achieved nuclear fusion, he said, harnessing the reaction that powers the sun to herald a future in which energy would be sold in "half-litre bottles, like milk". But things soon turned sour when researchers returned from Huemul to report that the whole thing was an expensive, embarrassing fraud.

The Huemul hoax was an extreme case. Arguably, though, it set a pattern for the long quest to harness star power for virtually limitless clean energy here on Earth: audacious claims followed by disappointment, rinse and repeat. It explains the tiresome persistence of the old joke that fusion has always been 30 years away, and always will be.

Yet here we are again. In the past year alone, private fusion firms have received more investment than in the entire history of this enterprise. "The feeling among investors is that fusion will happen," says Melanie Windridge, a fusion scientist and founder of Fusion Energy Insights, a membership organisation for the energy industry. Some companies are even promising commercial fusion reactors in a decade. "Progress is happening very rapidly," says Annie Kritcher at Lawrence Livermore National Laboratory (LLNL) in California. "As you get closer and closer, things start to take off."

What is hard to discern, however, is whether recent advances at big, state-funded fusion projects, together with new technologies and reactor designs in development at private firms, really amount to a tipping point. When you carefully unpack the hype, is it plausible that fusion reactors will be supplying electricity to grids by around 2030?

The basic physics of nuclear fusion is straightforward. Fission, which is what existing nuclear power plants do, releases energy from the decay of heavy atoms like uranium. Fusion, by contrast, involves fusing the atomic nuclei of very light elements, usually hydrogen, to form heavier nuclei. The total mass of every new nuclei formed is less than the mass of the original pair that fused to form it, and the missing mass is released as enormous amounts of energy. This is the process that powers the sun, after all.

Star power

Making a miniature sun on Earth is far from simple, however, because self-sustaining fusion only happens at the ludicrously high temperatures and pressures found in the cores of stars. Even if you successfully start fusion in the lab, the reaction will quickly fizzle out. "It's incredibly difficult," says Lee Margetts, a fusion scientist at the University of Manchester, UK. "We're trying to do what the sun is doing, without [producing] solar flares, and in a much smaller container."

Solar flares are intense eruptions of plasma, erratically bursting into space at millions of kilometres per hour. They are a hallmark of the immensely turbulent nature of this material – the superhot, supercharged state of matter in which fusion takes place in the sun's core. "Plasma is a wily, beautiful state of matter," says Windridge. As solar flares suggest, its behaviour is also hard to predict and even harder to control.

That is the challenge for those chasing fusion at experimental facilities across the world. In many cases, these use doughnut-shaped reactors called tokamaks, which deploy magnetic fields to levitate and so control the plasma while injecting energy to kick-start a fusion reaction. Only when you get your plasma hot and dense enough for long enough will you reach "ignition", meaning the fusion reaction becomes self-sustaining.

On this, there has been progress. In August, a team led by Yong-Su Na at Seoul National University in South Korea achieved a fusion reaction for 30 seconds at temperatures about six times that of the sun's core using the Korea Superconducting Tokamak Advanced Research (KSTAR) device. And in December 2021, at the Joint European Torus (JET) in Oxford, UK, researchers set a new global fusion record by producing 59 megajoules of heat energy in a reaction that lasted 5 seconds. "If you could hold it happily for 5 seconds, it suggests you could hold it happily for 5 hours," says Windridge.

Meanwhile, to avoid the trials of magnetically levitating plasma, Kritcher and her colleagues at LLNL's National Ignition Facility (NIF) are pursuing another technique called "inertial fusion". This involves aiming 192 powerful lasers at a peppercorn-sized capsule that implodes and crushes atoms together at its centre, creating a short, sharp burst of fusion. In August last year, NIF reported a world-first self-sustaining nuclear fusion reaction, whereby fusion creates enough heat to make more fusion happen. "That really was a big step forward," says Steve Cowley at Princeton University.

But ignition is just the start. These state-funded fusion experiments were never designed to be power stations. After fusion has briefly been achieved, the reactor is shut down, the results are pored over and the experiment is revamped. We can do fusion, says Cowley. "What we don't know is whether we can do it at a cost the consumer wants to pay for their electricity."

As if to hammer that point home, over the past year, NIF scientists have been unable to › repeat their self-sustaining reaction. Tiny imperfections in the imploding capsules can mean fragments of their diamond casing is shattered into the plasma, disrupting the fusion reaction. Oh, and each capsule currently costs around £1 million.

Even with the tried-and-tested tokamak design, experimental reactors can only run in short bursts. JET's 5-second record was limited by the reactor's copper coils, which overheat if they are bombarded for too long by the neutrons released during fusion. The unwieldy size and complexity of experimental tokamaks also means they can take decades to build – and many more years to master. The tokamak at the $22 billion International Thermonuclear Experimental Reactor (ITER) in France, which should fire up in the late 2020s, has been afflicted by the spiralling costs and delays that often plague big international science projects.

On top of all that, nobody has made the leap from ignition to net-energy generation. Obviously, getting more energy out than you put in is a prerequisite for any power station. NIF holds the current record, generating 70 per cent of the energy that was put into the imploding capsule. The team behind ITER says it will get out 10 times the energy that goes in – but not until 2035. And these figures don't take into account all the energy it takes to power the lasers – or, in the case of a tokamak, all of the energy needed to power the magnets. "The performance has to be a heck of a lot better before we get there," says Cowley.

Tony Donné, the programme manager of EUROfusion, a group of national fusion labs that includes JET, reckons we will be into the 2060s before any appreciable amount of electricity is being produced by fusion. All of which may leave you wondering why a profusion of private companies has landed on "commercial fusion in a decade" as a reasonable ambition.

There has certainly been a flurry of investment. According to the latest survey from the Fusion Industry Association (FIA) in Washington DC, the 30-odd companies it represents have declared private funding to the tune of $3 billion in the past year, plus an additional $117 million from governments.

One of the firms enjoying significant backing is Commonwealth Fusion Systems (CFS), based in Massachusetts, which has recently raised $1.8 billion after demonstrating magnets made from a novel high-temperature superconductor that pack twice as much power as those in today's best tokamaks. This should mean that you can put more pressure onto the fusion plasma, preventing heat from escaping, and allowing you to build smaller reactors. CFS claims it will have a reactor putting out more energy than goes in by 2025 – and producing electricity continuously by early 2030. "We're not so much in discovery mode, we're in execution mode," says Bob Mumgaard, the company's CEO.

He is keen to draw parallels with recent advances in human space flight spurred by private industry. "NASA's Space Shuttle and SpaceX's rocket are following the same laws of physics designed with the same tools, but executed for different goals by different types of organisations," says Mumgaard. By modernising rocket technology, and making rockets reusable, the likes of SpaceX have made space flight much cheaper.

Mumgaard's optimism also stems from the fact that the big, state-backed fusion projects have delivered a genuine understanding of the physics of plasma containment, which private companies hope to leverage to rapidly innovate and produce better reactors.

CYRIL ABAD/FUSION FOR ENERGY

A section of the ITER fusion experiment's huge vacuum chamber

"IS EVERY FUSION START-UP GOING TO SUCCEED? NO. BUT IS EVERYTHING WORTH TRYING? YES"

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CFS and others in the race to fusion are "building on the shoulders" of this new grasp of plasmas, says Mumgaard. In fact, a large part of the research that many public labs now do is running computer codes and doing calculations for private companies. "We're in that baton-passing phase," says Windridge. "People tend to be now viewing the main challenges in fusion as engineering challenges."

Which isn't to say these engineering challenges will be easy to overcome. Here again, though, there are signs of progress. CFS isn't alone in having raised investment off the back of demonstrations of technology – such as artificially intelligent plasma control, more powerful lasers or novel fuel sources – and new designs that push beyond the traditional tokamak doughnut.

Tokamak Energy in the UK and ENN in China, as well as the planned UK government-funded STEP reactor, will use a new type of spherical tokamak. This allows reactors to be even smaller because, for the same volume, spheres have a smaller surface area than doughnuts, so the magnetic fields can push more effectively. Like CFS, Tokamak Energy says it will have pilot reactors running in the mid-2020s, with commercial reactors following in the early 2030s.

Donné says these are "very aggressive timelines" because private companies don't factor in the learning curves you have to negotiate every time you upgrade or redesign a fusion reactor. When JET refurbished its tokamak reactor in the late 1990s, swapping its carbon walls for more advanced metal ones, it took the researchers five years to relearn how to use the machine. Donné reckons the promises of fusion in a decade are more attuned to the investors than the science.

Building smaller tokamaks undoubtedly presents fresh challenges, says Cowley, but the payoff is that you can make cheaper machines more quickly. He points out that, decades ago, cars used to break down all the time – but those days are gone because most faults have been eliminated over many iterations. Perhaps fusion engineers can do likewise.

Other companies are pushing radical new designs that they hope will circumvent the problems that have held back fusion reactors. "We deliberately picked our solutions to work around those engineering challenges," says Nick Hawker, CEO of Oxford-based company First Light Fusion (FLF), whose novel approach to inertial fusion mimics the snapping claw of a pistol shrimp.

Shock and claw

Yes, a shrimp. Pistol shrimps stun their prey by quickly closing their giant claw to create a focused shock wave in water, where temperatures rise briefly to extreme levels. For Hawker's PhD, he simulated that process and later built it into the technology that FLF uses to create fusion reactions. Instead of focusing many lasers onto a capsule, as occurs at NIF, FLF fires a projectile at high speed and then concentrates the energy onto the fusion fuel capsule using its shrimp-inspired approach. The plan is that it will make inertial fusion cheaper and easy to replicate. "Is every fusion start-up going to succeed? No, probably not," says Hawker. "Is everything worth trying? Yes."

Many new companies have picked up blueprints discarded by public labs, adapting them and integrating new technology. Canadian company General Fusion, for instance, is betting on a cross between a tokamak and inertial confinement, using magnetic fields to levitate the plasma, followed by liquid metal pistons to compress it. This concept came out of the US Naval Research Laboratory in the 1970s, but without the electronics to synchronise their pistons precisely enough – and so symmetrically compress the plasma – it failed. "With the better technology that we have today, and the advances in the plasma physics, we can pull it off," says the firm's founder Michel Laberge.

JEAN-MARIE HOSATTE/GAMMA RAPHO/GETTY IMAGES

Fully assembled, ITER's tokamak will weigh in at 23,000 tonnes

General Fusion's design has the potential to leap one key hurdle in particular: making fusion fuel. A common fusion fuel is tritium, a form of hydrogen, which has to be produced in a separate process to fusion itself. This is a vital part of any operation, but most companies seem to have ignored it, says Donné: "It's like selling a car without having petrol stations around." But General Fusion is different. The fusion reaction is surrounded by a jacket of liquid metal that includes some lithium. This jacket absorbs the heat effectively – and at the same time some of the lithium is turned into tritium, producing new fission fuel.

It remains to be seen if solutions like this can work in practice. Even if they do, no-one has yet built the gubbins that would surround a reactor to make electricity non-stop. Exhaust systems, heat exchangers, turbines – all of it must be custom-built from materials that can withstand the high-energy neutrons released during fusion. "Unless these companies have a secret research line in materials, after a few months of operation [the reactors] will simply fall apart," says Donné.

So where does all this leave fusion? Clearly, there is a lot of engineering to do before the dream of bottling the power of stars becomes a reality. The private fusion companies argue that all it requires is proper investment, at a scale proportional to the size of the task and the potential payoff – and it is certainly true that fusion has never really received proper backing from governments. "It doesn't make it easy to keep the pace," says Donné.

But Cowley warns that we should be careful about comparisons with the space industry. "We'd been to the moon before SpaceX was conceived, we'd launched hundreds of satellites," he says. "There's a lot of difference between that and where we are in fusion because we've never made any electricity from fusion. At all." ∎

Thomas Lewton is a science journalist based in London

Life from death

Ecologists have neglected mortality's role in maintaining ecosystems, says **Laura Spinney**

TO THE east of Amsterdam lies a tract of reclaimed marshland, the site of an epic rewilding project called the Oostvaardersplassen. It is sometimes nicknamed the Dutch Serengeti because of the profusion of large herbivores that graze there. But during the bitterly cold winter of 2017-18, deeply shocking images began to emerge. Thousands of deer, cattle and horses lay dead or dying of starvation. Desperate onlookers threw bales of hay over fences in an effort to help – clearly something had gone badly wrong.

Theoretical ecologist André de Roos was neither shocked nor surprised. His research had predicted this disaster years earlier. Without the herbivores' natural predators, he reported, overpopulation was unavoidable – leading to mass death when food ran out. The cold weather may have accelerated the die-off, but it would have happened anyway. "There were only ever two options: to allow mass starvation or to introduce culling," says de Roos. One way or another, nature has what he calls a "requirement for mortality".

This requirement takes centre stage in de Roos's work. But it is often unrecognised by other ecologists, whose models fail to account for the complexity within any population – in particular, the fact that individuals may vary hugely depending on their stage in life, which can result in intergenerational conflict. As well as highlighting the benefits of death, de Roos's thinking can explain some of the toughest brain-teasers in ecology. It also suggests novel ways of tackling economically important problems, such as the collapse of fisheries and the impact of noise pollution on marine mammals. Perhaps it is time we took it seriously.

Ecology's classical models of how species interact – the Lotka-Volterra equations devised in the early 20th century – treat every individual in a population as identical. De Roos, who is based at the University of Amsterdam and at the Santa Fe Institute in New Mexico, thinks this simplification isn't justified – and potentially invalidates any predictions the models make. He points out that it is antithetical to Charles Darwin's teaching that there is variability among individuals and that natural selection operates on that variability.

"The biggest source of variation is that individuals go through a life cycle," he says. Between a fertilised egg and an adult, an individual's weight might increase as much as a billion times, depending on the organism. That requires resources. In most species, maturation isn't dependent on age but on resources. Reproduction is also resource-dependent, and only a lucky few pull it off. Just 1 per cent of butterflies' eggs become butterflies, for example. Juveniles and adults have different predation risks too. Essentially, they occupy different ecologies, but the field's classical models take no account of that. The question de Roos asked himself nearly 30 years ago was: would it change our understanding of ecosystem dynamics if they did?

The answer from his first forays into research was yes. Ever since, he has pursued a "life history" approach, building developmental stage into his ecological models. This means that he accounts for how the available resources affect a population's structure – the ratio of developing juveniles to reproductive

›

The death of one individual may benefit another

ALEXIA KHRUSCHEVA/GETTY IMAGES

adults, say – as well as how the population's changing structure affects those resources. "He closes the loop," says Sebastian Diehl at Umeå University, Sweden, one of de Roos's former collaborators.

It doesn't sound too radical, but this approach often generates counter-intuitive results. Take the brown trout in Lake Takvatn, northern Norway. Following a collapse in trout numbers as a result of overfishing, de Roos and Lennart Persson at Umeå University carried out a five-year cull of its prey, Arctic char. Killing its prey increased the trout population and the recovery persisted for years after the cull ended. To make sense of this, consider what happened to char. With fewer trout, their numbers grew, but this also increased the competition for food between char. As a result, their size and condition declined, so it took them longer to mature. This meant there were fewer newborns, which is what brown trout eat. Removing adult char relaxed that competition, leading to a proliferation of the trout's favourite food – and eventually of the trout.

The fact that the recovery was maintained long after the cull ended shows that it is possible to nudge an ecosystem into a different stable state. In fact, one of the more profound messages of de Roos's work is that the different life stages hold each other in tension and can settle into different equilibria depending on how the environment changes, says Simon Levin at Princeton University. "If an organism lived forever, its genes would be doomed because it doesn't have the capacity to adapt to a changing environment," he says. "Selection pressures therefore operate in multiple ways to break up gene combinations that are good in the short run, and to replace them with combinations that are better in the new environments." Mutation and recombination are two ways in which gene combinations are broken up; population restructuring is a third.

The most extreme example of the intergenerational conflict that underpins population restructuring is cannibalism. It is widespread in the animal kingdom and was even practised by humans until it became a taboo. If adults and juveniles of the same species share an environment, and it becomes impoverished – water levels drop, say – they start to compete for a dwindling food supply. The adults may take to eating the juveniles, which makes evolutionary sense, says de Roos, because it increases the likelihood that at least some individuals of the species will survive.

Intergenerational conflict exists even when individuals of different life stages occupy different environments. Think of tadpoles in a small pond, which become frogs in a large forest. The forest is bountiful, so many frogs successfully reproduce and deposit lots of eggs back into the pond. But then the pond becomes overcrowded and food becomes scarce, so the tadpoles develop more slowly and are vulnerable to predators for longer. As a result, fewer adults emerge into the forest. "The outcome is counter-intuitive in the sense that the resource-rich environment, the forest, contains few adults, while the poorly resourced one contains many tadpoles," says Diehl.

Mystery of the missing cod

In 1992, the Canadian fisheries minister declared a moratorium on cod fishing off Newfoundland, ending a way of life for local people that had persisted for 500 years. Four years later, ecologists predicted that cod stocks, which had collapsed as a result of overfishing, would recover within a decade. They still haven't. Everyone agrees that the reasons for this are multiple – and include illegal trawling. But one explanation, suggested by André de Roos at the University of Amsterdam in the Netherlands, is especially surprising.

He feels that not enough attention has been paid to the Atlantic cod's main prey, capelin. Since the cod collapsed, capelin have increased in number but decreased in average size. A concomitant drop in the abundance of their preferred food, zooplankton, suggests the reason might be increased competition among them for that food. Culling capelin seems like a bizarre way to promote the cod's recovery, but de Roos thinks it could work. His models are based on a radical revision of classical ecological theory, and although he hasn't studied Atlantic cod, he has found a similar effect elsewhere (see main story).

Unsurprisingly, not everyone is convinced. Indeed, some Scandinavian ecologists have been calling for the opposite approach in the Baltic Sea, where overfishing has also reduced cod numbers. They want a major reduction in fishing quotas for sprat and herring, two fish that cod prey on there. Meanwhile, Peter Abrams at the University of Toronto, Canada, thinks the problem may lie elsewhere in the complex food web to which Atlantic cod belong. He says that de Roos and other ecologists have failed to consider other species in that web, including ones that prey on cod, such as seals. "To me, that's a more important omission," says Abrams.

GORDON PETERSEN/DESIGN PICS INC/ALAMY

Competition between generations may have stunted the recovery of certain fish populations

Nature has a requirement for mortality

PIERRE CROM/GETTY IMAGES

Another surprising result is that two predators preying on the same species may sustain rather than endanger each other. If the first preys on juveniles, it relaxes competition between these young animals for food, meaning that more of them mature, producing more food for a second predator that prefers eating adults. The second predator, in turn, reduces the adult population so that more of them reproduce, generating more food for the first. "In classic theory, in which population structure is ignored, even the co-existence of two predators foraging on the same prey is impossible – let alone that they would facilitate each other," says de Roos.

He thinks his models could make a significant impact in the real world, if only other ecologists would take them seriously. He has found similar dynamics to those he observed in Lake Takvatn in the Baltic Sea, for example, where overfishing of cod has been accompanied by huge increases in numbers of its prey, sprat, along with reductions in the sprats' size and condition. These models might also help explain why some Atlantic cod stocks have failed to recover from a collapse despite a three-decade ban on fishing (see "Mystery of the missing cod", left).

De Roos's latest research concerns the effect of noise pollution on whales. The US Navy conducts submarine war games off the country's coast that involve sonar, and it is legally obliged to gauge the environmental impact of those exercises. Until recently, the prevailing view among researchers was that the noise confused beaked whales, causing them to retreat from their habitual foraging grounds. Pregnant females were thought to be at risk of dying or losing a calf as a result.

Working with conservation biologist John Harwood at the University of St Andrews in the UK, de Roos has found that, in fact, only a small subset of pregnant females – youngsters nursing their first or second calf, that are often still growing themselves – is adversely affected by the sonar. Moreover, this has a positive effect on the population as a whole. "All the others do better because there are more resources and less competition," says de Roos, and the average number of calves per female goes up. When he and Harwood produce their final report for the US Navy, it is likely to cause much head-scratching over what constitutes a harmful environment.

De Roos has latterly turned his mind to biodiversity in general. Conventional wisdom holds that having a wide range of species present begets stable ecosystems. But in the 1970s, population biologist Robert May used classical models to show that the more interacting species there are, the more instability that should, in theory, generate. Ever since, ecologists have been struggling to explain why diverse ecosystems aren't wildly unstable. "What this body of work entirely assumed was that species are homogeneous – if you've seen one individual of species X, you have seen them all," says Robert Holt at the University of Florida. De Roos, unsurprisingly, took issue with that. By injecting life history into the models used by May, last year he showed that the resulting feedback loops help stabilise even rich, multispecies communities.

At the sharp end

Given such successes, you might expect de Roos's ideas to be mainstream by now. Asked why ecology has snubbed him, he replies that he doesn't think it has. "Colleagues are impressed by the work and the results," he says. "But at the same time, they are intimidated by the complexity of the models, by the complexity of the methods you might need to investigate them, by the complexity and unfamiliarity of the results that emerge." This is particularly problematic for ecologists working at the sharp end, managing real-world problems. "They often lack the support, resources or network to stay on the cutting edge," says Mary O'Connor at the University of British Columbia in Vancouver, Canada.

Not everyone is entirely convinced by the emphasis on life history, though. Theoretical ecologist Peter Abrams at the University of Toronto, Canada, says that is just one of many factors that classical ecology overlooks. In 2005, he and Hiroyuki Matsuda at Yokohama National University in Japan coined the term "hydra effect", after the many-headed serpent of Greek myth that sprouted two heads for each one Hercules sliced off, to describe any situation in which a higher death rate causes a species' population to rise. Their description of the phenomenon doesn't take life stage into account, and although Abrams agrees that life history might shape some systems, he suspects it is irrelevant in others. The toxic algal blooms that clog certain lakes each summer, for example, are best understood not in terms of life history, but in terms of the interactions of the microbial culprits with other microbes.

But de Roos does have a handful of loyal supporters, including Diehl. "The problems that we deal with in ecology are typically hard, and that means the predictive power of models is often limited," he says. Ecology is complex, making it hard to untangle the various processes and come to simple conclusions. It can be frustrating, Diehl adds. "But if we don't develop [life history] theory further, we may be looking for the wrong things in our data."

After all, most ecologists failed to see that the booming grazers of the Dutch Serengeti were heading for bust. They learned it the hard way and the reputation of rewilding took an avoidable hit in the process. It is time this mindset changed, says de Roos. When it comes to nature, we need to see the upside of death. ∎

Laura Spinney is a writer based in Paris, France, and author of *Pale Rider: The Spanish flu of 1918 and how it changed the world*

Improve your digital diet

Online activities can actually boost your well-being – if you know what to consume and how to consume it, finds **Carissa Wong**

LISA SHEEHAN

THE year is 2032 and you are at the cutting edge of a revolution. You have just received a blueprint for your personal digital diet. It prescribes a menu of tweaks to your online behaviour that will keep “Zoom fatigue” at bay, curb mindless scrolling and fill your social media interactions with meaning. There is even a regular dose of gaming to boost working memory and attention. Welcome to a new life of digital contentment.

Such a future may seem far-fetched, but hand-tailored digital prescriptions could be a reality within a decade, according to those working to understand how the internet affects our health and happiness. For many years, perceived links between screen time and well-being have fuelled widespread fears that digital technology is harmful to us. Now, there is a growing realisation that quality matters more than quantity, and that our focus on screen time is misguided.

Drawing parallels between what we consume online and the foods we eat turns out to be a more fruitful approach. Just as salads are better for us than cream buns, so some aspects of our digital diet are more nourishing than others. However, what constitutes healthy eating differs from person to person depending on our physiology and, likewise, there is no such thing as a universal healthy digital diet. In future, a personalised digital prescription could take all of this into account. For now, though, researchers scrutinising what we consume online are starting to distinguish the healthy from the not so healthy. In doing so, they are identifying online habits you can adopt to improve your digital diet and well-being.

One prominent critic of the supposed link between time spent online and poor well-being is Amy Orben at the University of Cambridge. “The assumption was that time would be the unit of importance and that we could put limits on screen time as we have for units of alcohol,” she says. “But there is very little evidence of a clear dose-response relationship”

Orben outlined her argument in a paper published in 2021, in which she also introduced the digital diet concept. Since then, Orben and her colleagues have shown that most online activities have only a tiny effect on well-being – in terms of diet,equivalent to eating potatoes, they concluded, which can, of course, be eaten safely in moderate quantities. Meanwhile, a growing number of researchers now see limiting screen time as a simplistic approach to managing our well-being. “It is the equivalent to asking: is food good for you? And ignoring what exactly is being eaten, who is eating and what else they have going on at school, work or home,” says Isabela Granic at McMaster University in Canada.

“Nutritional labels on video games could inform people’s choices”

To be clear, nobody denies that excessive internet use can be harmful for some people. Research shows that those most susceptible to online addictive behaviours tend to have a history of negative childhood experiences, reduced self-control and may even have certain mutations in genes that affect how the “happy” hormones, dopamine and serotonin, signal in the brain. Being younger and male increases your risk of addiction to online gaming. And social media can undermine life satisfaction at particular ages during adolescence: on average, males are most sensitive at age 14, 15 and 19, and females at age 11 to 13, and 19.

Also, there is no doubt that some internet platforms are designed to draw us in. Social media such as Facebook, Twitter, TikTok and Instagram do this through likes and positive comments, which tap into a “feels better” neural circuit in the reward centre of the brain. This reward processing brings pleasure and alleviates negative moods, but according to some researchers, it could become addictive.

However, viewing problematic social media use in terms of addiction can be stigmatising, and Orben believes that, for most people, the diet analogy is a better way of looking at the problem. She sees social media platforms as the digital equivalent of carbohydrates because they come in many varieties, with some delivering the equivalent of a sugar high. We may be tempted to overindulge in carbs, but this isn’t generally seen as addiction and the same goes for social media overuse.

Some researchers believe we would do better to think in terms of a mental state associated with daydreaming or listening to music. Called normative dissociation, it involves a narrowing in attention that excludes thoughts, feelings, memories and awareness of the external world, including the passage of time. As a result, dissociation reduces self-awareness and reflection so that people only realise they have “spaced out” after the fact.

Research by Amanda Baughan at the University of Washington in Seattle and her colleagues suggests that social media platforms seem to induce this state, leading some people to scroll for longer than they would like. The team recruited 43 participants to spend a month accessing Twitter using a custom-built app called Chirp.

Throughout the study, participants were asked how strongly they agreed, on a scale of 1 to 5, with the statement “I am currently using Chirp without really paying attention to what I am doing”. This revealed that 42 per cent of participants dissociated for a third of the

JACEK MAKOWICZ/ALAMY

time they spent on Chirp. Follow-up interviews with 11 of them found that thoughtless scrolling could provoke feelings of regret.

The team then tested whether adding features to Chirp could reduce dissociation. Two add-ons – screen-time notifications and statistical displays of usage patterns – worked for some people. But the most successful approaches entailed cutting news feeds into smaller portions. One tool forced users to filter content into lists such as "friends" and "sports" instead of browsing the unfiltered home news feed. Another flagged up previously viewed content in reading history lists. Used together, these significantly reduced dissociation. What's more, although people spent just as long on Chirp, they enjoyed the app more.

"Lists allow the content you're consuming to be in much smaller chunks, helping you to disengage from mindless scrolling," says Baughan. "If you're feeling unhappy with your social media use, this certainly seems to be worth trying." The good news is that similar lists are already available on Twitter and Facebook, although they aren't a default setting.

Jocelyn Brewer, a psychologist based in Sydney, Australia, also believes we can get more from our time online without necessarily consuming less. "We need to find ways to tune into our digital hunger and eat intuitively," says Brewer. She identifies three steps to reduce the regret that people often feel from online overindulgence. The first is to be mindful – to consider your intentions before you go online. The second is to look for meaning – to only read or participate in things that align with your goals and contribute positively to your life and overall sense of wellness. "And lastly, try to moderate your actions. Before you go to comment or post something on social media, ask yourself what might happen if you refrained from doing so," she says.

Unsurprisingly, many scientists agree that reflection and mindfulness can help us avoid mindless scrolling. But it is also important to avoid being too hard on yourself if you haven't yet found the sweet spot. "My hunch is that the guilt and stigma we feel about using technology probably has a worse effect on well-being than any effects of the digital activity itself," says Granic. She plans to explore how our social media experience is affected by having either a negative or positive mindset.

There is already evidence that mindset matters when it comes to online gaming. Andrew Przybylski at the University of Oxford and his colleagues analysed six weeks of video-gaming data from nearly 39,000 people. They studied seven games, including *Animal Crossing: New horizons* and *Gran Turismo Sport*. By surveying the participants every two weeks, the team found that people who saw gaming as a means to relax and socialise were positively impacted by gameplay, while those who felt a compulsion to play, for example due to peer pressure or a need to achieve certain gaming goals, were less satisfied with their experience. "If you see it in a positive way, that will have a positive impact on your well-being," says Przybylski.

The study also provided the strongest evidence yet that how long you spend gaming has no significant impact on your well-being. "Our study really allowed us to look for a causal link between actual time spent playing games and well-being over the six weeks and, ultimately, we found none," he says.

Better still, there is growing evidence that playing certain video games can boost your cognitive skills. Previous studies have found links between online gaming and improvements in visual-processing skills, attention and working memory. However, most didn't account for potentially confounding factors, such as participants' socioeconomic status or baseline intelligence.

Bruno Sauce at Vrije University Amsterdam in the Netherlands and his colleagues controlled for these factors in a recent study, which analysed data from thousands of children to reveal that spending more time gaming was linked to gains in intelligence two years later, compared to those who didn't game. Sauce speculates that these cognitive benefits could eventually translate to better well-being. "Previous studies have shown that IQ predicts future happiness, it predicts future marital satisfaction, it predicts future longevity," he says.

MASKOT/GETTY IMAGES

Social media platforms can cause us to switch off from our surroundings

Online gaming may help to increase attention and focus

Sauce's team didn't explore whether different game genres have distinct cognitive effects. However, we already know that shooter games are especially good at improving people's ability to focus their attention and make fast decisions, without making them more impulsive. If other genres prove to have specific benefits, Sauce believes we could use this information to help improve our digital diet. "If we could have nutritional labels on video games like we do for foods – that say how much this or that game increases attention, visual-spatial abilities or boosts long-term memory – that could be really useful to inform your choices," he says.

People are free to decide whether or not to spend time gaming and on social media, but, increasingly, we are compelled to engage in another potentially problematic online activity: videoconferencing. Research shows that video calls can harm well-being and creativity. This will ring true if you have ever experienced "Zoom fatigue", the feeling of exhaustion associated with video calls. Recent research indicates that cutting the length of such calls or, better yet, taking more breaks between meetings, reduces related tiredness. The study, by Géraldine Fauville at the University of Gothenburg in Sweden and her colleagues, also suggests several ways to make videoconferencing a more positive experience.

The researchers created a scale that addressed aspects of mental, visual, social, motivational and emotional fatigue while videoconferencing. Their survey of more than 10,000 people revealed that the strongest cause of fatigue was feeling physically trapped in the camera's field of view. Fauville suggests moving further away from your camera and using a standing desk to increase your range of movement during a call.

Another factor was "hypergaze". "During video calls, large faces are constantly staring at you," she says. "This hypergaze and apparent physical proximity between people is perceived by the brain as a situation that would lead typically to mating or conflict." Shrinking the size of your video-call window can help avoid this.

Then there is mirror anxiety – the negative feeling associated with watching oneself on screen. Women are especially prone to this, which might help explain why they tended to experience more "Zoom fatigue" than men. Fauville suggests turning off the self-view pane after you first enter a video call and switching off your video when you can. There's another good reason to do the latter. "In a video call, you have to intensify your gestures and work harder to interpret others' non-verbal cues, which is mentally demanding," says Fauville. In fact, she thinks that audio-only calls should be the default. "It was an assumption that being able to see each other online would make it feel more natural, but perhaps we've got ahead of ourselves," she says.

The human screenome

Certainly, when it comes to understanding the wider impacts of digital technology on well-being, there is still a lot we don't know. Filling these gaps is tricky, not least because it requires social media and online gaming companies to share more of their real-world data than they currently do.

Doubtful that this will happen, researchers at Stanford University in California have launched the Human Screenome Project, an initiative that uses specially designed software to collect data from volunteers' phones by recording, encrypting and transmitting screenshots every 5 seconds whenever a device is on. By capturing the moment-to-moment changes on a person's screen, the researchers hope to uncover links between well-being and digital technology in higher resolution than ever before.

Przybylski is more optimistic that online companies will be forthcoming with their data, making personalised prescriptions for healthy digital diets possible sooner than you might think. This would entail monitoring a person's digital habits and well-being, predicting the effects of their actions and prescribing behavioural changes to maximise their future happiness and productivity. "If we fund it appropriately and treat it like the Human Genome Project, but for our online social lives, it could happen in a decade," he says. ∎

TOP TIPS FOR ONLINE WELL-BEING

STREAMLINE YOUR SCROLLING
Sort your social media news feeds into lists based on topics to help tackle excessive scrolling.

BE MINDFUL
To help reduce feelings of guilt and regret, reflect on how your time online makes you feel.

ADOPT A POSITIVE MINDSET
Gaming can boost well-being if you feel good about it, and the same may be true of social media use.

DON'T WATCH YOURSELF
Switch off the self-view pane on video calls to avoid critically analysing yourself.

DITCH THE VIDEO
Where possible, make conference calls audio-only to help combat "Zoom fatigue".

Carissa Wong is a junior reporter at *New Scientist*

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Citizen science

Blooming algae

Put your local pond under the microscope to help a project tracking algal growth around the world, says **Layal Liverpool**

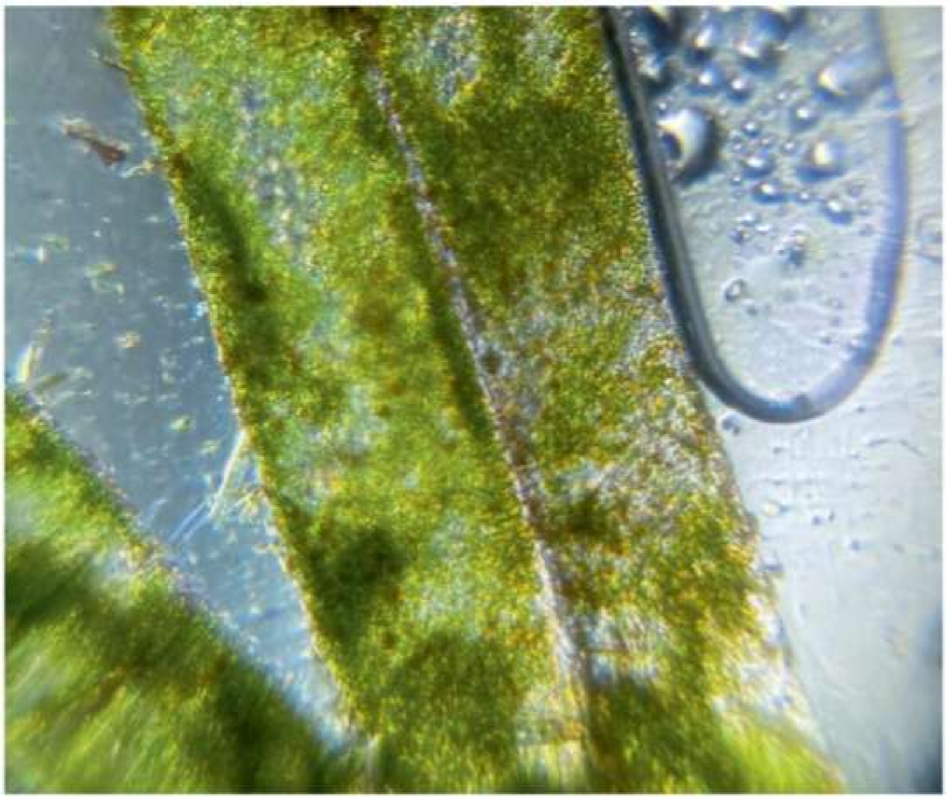
Layal Liverpool is a science journalist based in Berlin. She believes everyone can be a scientist, including you. @layallivs

What you need

Access to a lake or pond
Algal monitoring equipment provided by the Open Field Collective can be found at openfieldcollective.org
A smartphone

Citizen science appears every four weeks

Next week
The science of cooking



LAYAL LIVERPOOL

LEANING over the water's edge, I spot what I am looking for. I take out my tweezers and tug, pulling off a small piece of algae and transferring it into a plastic tube. I top my sample off with a few drops of pond water, squeezed up through a little pipette.

I am one of a growing number of international volunteers helping to monitor the health of the environment by sampling diverse aquatic ecosystems through the Algal Bloom Monitoring project, a citizen science initiative run by the US-based Open Field Collective (OFC).

Before I head home, I snap a few photos of the pond and write down some observations, prompted by the handy protocol on the OFC's website. Today, I note that the algae appear as "rooted plants" and that the water smells "leafy". Holding my sample up towards the sky, I also record that the water looks clear.

Back home, I dip a pH strip into my sample and record the pH as a neutral 7, based on the colour change I observe. Afterwards, it takes me less than 5 minutes to convert my smartphone into a microscope using a foldscope, a foldable microscope attachment made largely of cardboard, which I use to take a closer look at the algae I have collected. I zoom in and snap some photos to complete my data collection, before submitting my observations via the OFC's website.

All the equipment I used fitted into an A4-sized envelope and was sent to me by post after I signed up. If you are keen to get involved, you can register your interest via the contact form on the OFC's website. The project is open to groups, including schools, as well as solo algae enthusiasts like me.

Participants are also sent a portable spectroscope, which can determine the density of algae in a sample based on the way light travels through it. This helps with the detection of algal blooms, algae that have become overgrown and can harm wildlife by depleting oxygen from the water, in some cases leading to an accumulation of toxins. There is evidence that these harmful algal blooms are becoming more common in freshwater lakes worldwide.

That is all the more reason why observations collected and submitted by volunteers are helpful for researchers, including Ikbal Choudhury and Ankita Jha at the OFC, as they enable them to monitor the health of aquatic ecosystems around the world.

Data collected by volunteers in southern India this year showed an increased abundance of algae in water samples, starting in March and continuing through the summer months. This trend isn't unexpected, but it is reassuring to Choudhury and Jha because it suggests the information collected through the project so far is valid, and that it could also help to detect longer-term trends driven by factors such as climate change and pollution. ▮

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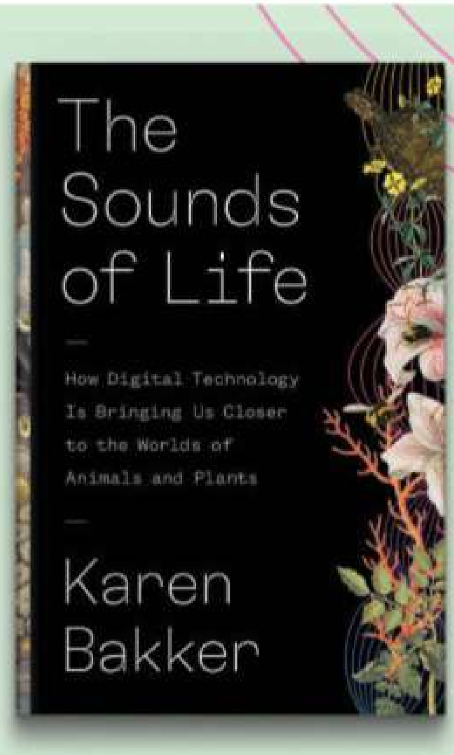
The Sounds of Life
How Digital Technology Is Bringing Us Closer to the Worlds of Animals and Plants
Karen Bakker

An amazing journey
into the hidden realm
of nature's sounds

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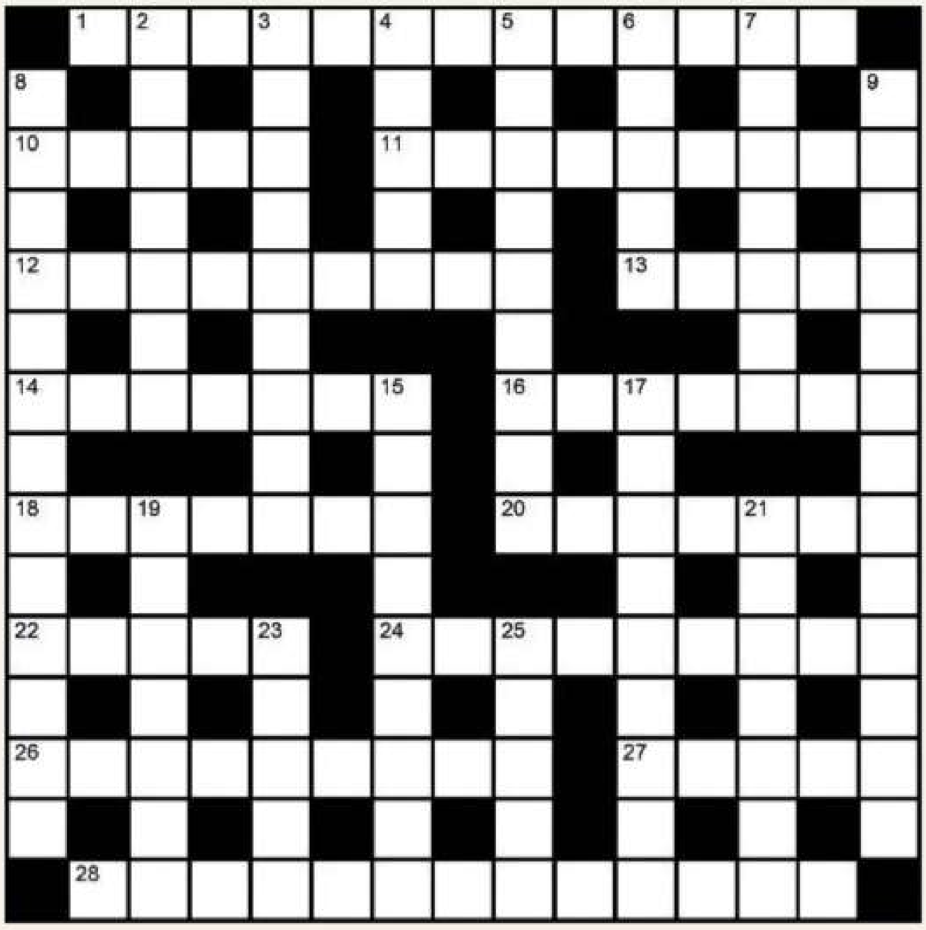
Quick crossword #119 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Extremely modern; cutting-edge (2-2-3-6)
10 William ___, US naturalist and deep-sea explorer (5)
11 ZnO (4,5)
12 Chickenpox (9)
13 Injection of fluid into the bowel (5)
14 Si (7)
16 Was; lived (7)
18 White or whitish, scientifically (7)
20 Gone the way of the dodo (7)
22 Bacterium associated with food poisoning (1,4)
24 Relating to the flight of missiles (9)
26 Of or relating to the "father of geometry" (9)
27 Unhatched (2,3)
28 Complete absence of light (5,8)

DOWN

2 Relating to membranes around the lungs (7)
3 $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$ (5,4)
4 Nut-bearing tree in the genus *Corylus* (5)
5 Mn (9)
6 Loop (5)
7 Three-pronged fork (7)
8 Informal term describing orthometric height (5,3,5)
9 Instrument used in security and mineral prospecting (5,8)
15 Epistaxis (9)
17 Insight arrived at without conscious reasoning (9)
19 Respiratory airways (7)
21 ___ oxide, laughing gas (7)
23 Relating to part of the hip bone (5)
25 Of the moon (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #174

1 Which of these wasn't classed as "megadiverse" by Conservation International in 1998: Venezuela, Argentina or the US?

2 There are two genera of sloth species, *Bradypus* and what else?

3 Who discovered ribosomes, the tiny structures in cells in which proteins are made?

4 Our sun's activity fluctuates in a cycle that lasts approximately how many years?

5 Sigmund Freud proposed that the human psyche could be divided into three parts: the ego, superego and what?

Answers on page 55

Puzzle

set by Zoe Mensch

#190 All square

The secretary of my tennis club has just changed the six-digit code for the padlock at the entrance gate. "As a mathematician, you will be interested to know that the new code is a square number," he said.

"Really?" I replied, only mildly interested.

"The code is also the final score of the three-set league match I played last week."

"And you have other clues to help me?"

"No, that's it," he said. And he was right. After a few "aha" moments, I narrowed the possibilities to a small range, and with the aid of a calculator discovered that there is only one "proper" three-set tennis result that is a square. Can you find it?

(A reminder of tennis scoring: the first person to win six games with a lead of two games wins the set, such as 6-3 or 6-4. However, if it goes to 5-5, the first to 7-5 wins; and if it goes to 6-6, there is a tie-break, the victor of which wins the set 7-6. First to win two sets wins the match and the eventual winner's games are always published first. If the score was 7-6, 2-6, 6-3, the padlock code would be 762663.)

Solution next week

Taste test

Do fizzy drinks really taste different from cans or plastic/glass bottles? My friend prefers cans, but I can't taste any difference.

@lozzinna69
via Twitter
I like a can best for most things, although Irn-Bru is best from a glass bottle. Beer of the same brand also tastes different from a can, bottle or draft.

@Tamereth
via Twitter
They all taste different. I always prefer cans over plastic bottles. Glass bottles are best.

@berneseo2
via Twitter
Drinks are so much better from a bottle. There is a metallic effect from a can.

In my opinion, cans have to be super cold to taste good, but you can get away with room temperature with a bottle.

> "The nature of the packaging and the sound of opening it can influence our expectations of what a drink will taste like"

Charles Spence
University of Oxford, UK
There are certainly psychological effects linked to the weight differences of the bottles and cans that drinks are served in, as well as cultural knowledge about different kinds of drink normally coming in each format. Simply adding a small weight to the bottom of a can of fizzy drink makes it seem to taste better.

As far as cultural factors are concerned, in the UK, people expect mass-produced beer to be sold in a tin. In the US, that preconception is changing with the craft beer revolution, meaning that US consumers are now starting to accept that quality beer can also come in a can.

What we expect, based on packaging, can bias the subsequent tasting experience.

In 2016, I and my colleagues published a study on this effect with Andrew Barnett of Scottish brewer Barney's Beer. It was conducted at the Edinburgh Science Festival.

For this research, participants were served the same batch of beer in a plastic cup that they had seen being poured from either a can or a bottle. People rated the beer that they knew had come from a bottle as tasting significantly better, even though it was exactly the same as the beer that had been poured from a can. No such preference was reported in a blind tasting, in which the participants didn't know if the beer had come from a bottle or can.

Of course, one shouldn't forget the possible impact of differences in the sound of opening a drink either. This can influence both our sensory expectations about what it will taste like and our hedonic expectations about how much we think that we are going to enjoy the experience. There is a bit of Pavlov's dogs in all of us.

SHUTTERSTOCK/JIRANART AONNOUM

Why do threaded fixings only ever seem to loosen on their own, not tighten?

This week's new questions

Turn of the screw **Why do loose screws only get looser and not the other way round, even if there seems to be no resistance to the latter?** ***Bob Falconer***, *Winchester, Hampshire, UK*

Memory overload **Is it theoretically possible for our memory to become full to the point where it can no longer record information?** ***Ben Walsh***, *London, UK*

Code limits

Are there limitless permutations of QR codes or are they recycled after a prescribed length of time?

Peter Steyn
Chattanooga, Tennessee, US
QR (short for "quick response") codes, invented in 1994 by the Japanese manufacturer Denso Wave, are often a 32×32 matrix of squares that are either black or white. As such there are a total of 1024 squares and a total of 2^{1024} variations are possible, which is on a par with 10^{308}. Given that scientists estimate that there are 10^{80} atoms in the universe, it is safe to say that we won't be running out of QR codes any time soon.

Garry Trethewey
Arkaroola, South Australia
Although not actually limitless, this is the case for practical purposes. There is no provision for recycling "used" QR codes. There is also no security – a counterfeiter can copy your QR code.

There are about 40 standards for building QR codes, and your QR code-reading device, like a phone, has to know 40 ways of interpreting the information into a useful form, such as a URL.

So far, the number of squares on QR codes has increased from 21×21 to 177×177. If they were to start running out, a new standard would be instituted, limited only, perhaps, by the quality of your phone's camera.

Ron Dippold
San Diego, California, US
QR codes encode a fixed number of bits, so they are finite, but it isn't really a problem.

There are many types of QR code – those that are smaller or larger overall, or with smaller or larger sub-squares. The ones you are used to seeing are Model 1 or Model 2. Model 1 can hold up to 24 spaces of 45 different characters (A-Z, 0-9, $%*+-./:). Model 2 can encode up to 47 spaces of those 45 characters. That gives $45^{47} = 5 \times 10^{77}$ full-length combinations.

But they aren't used like that. Your phone just expects a URL like "newscientist.com?qr=ABCD1234". Each owner of a prefix (such as newscientist.com) manages their own space and knows what "?qr=ABCD1234" means to them.

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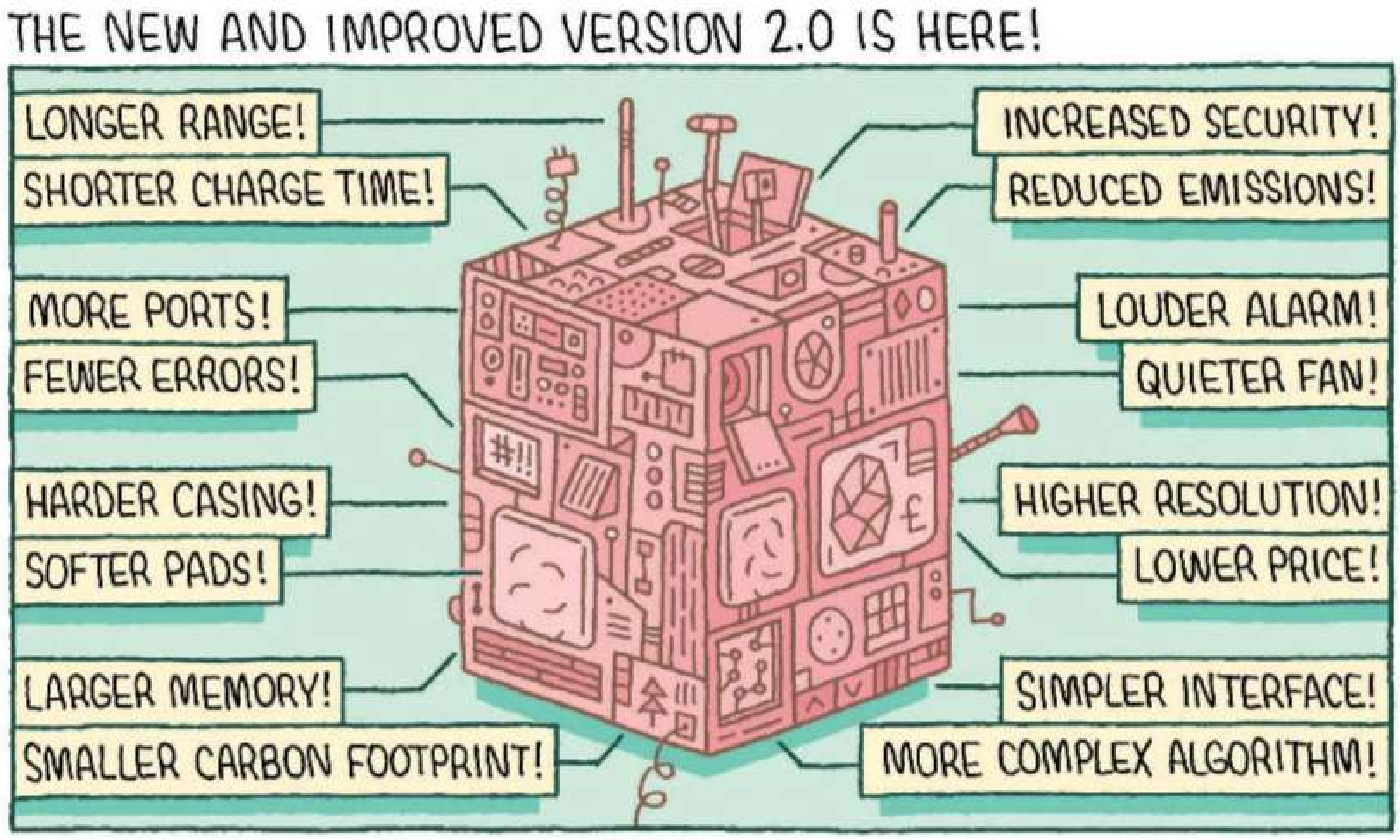
Tom Gauld
for New Scientist


THE NEW AND IMPROVED VERSION 2.0 IS HERE!
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SHORTER CHARGE TIME!
MORE PORTS!
FEWER ERRORS!
HARDER CASING!
SOFTER PADS!
LARGER MEMORY!
SMALLER CARBON FOOTPRINT!
INCREASED SECURITY!
REDUCED EMISSIONS!
LOUDER ALARM!
QUIETER FAN!
HIGHER RESOLUTION!
LOWER PRICE!
SIMPLER INTERFACE!
MORE COMPLEX ALGORITHM!

Since "newscientist.com?" takes up 17 characters, that leaves 30 characters – which is effectively infinite if used smartly.

QR codes are also used for entirely contextual applications. My company has tiny QR codes printed on our circuit boards that can only hold 10 numerals. The first three numbers are the board type and version, and the other seven are the serial number. If anyone else scans those, they won't know what they mean. And if we ever sell 10 million units, we will need to move to a QR code model with more permutations.

Herman D'Hondt
Sydney, Australia

Let us start with two observations. First, nothing is ever limitless; the limit may far exceed the expected use, but there is always a limit.

Then, consider the fact that most QR codes are used to send you to a website, so they encode a URL of typically 50 characters. URLs of more than 100 characters are very rare.

Now, let us look at the QR codes themselves. These can, for example, have a size of up to 177×177, or 31,329 dots. That is enough to represent more than 4000 characters, or something like 750 words. A typical novel may have 300 words per page, so a QR code can store well over two pages of text. That means that QR codes aren't limited to URLs, they can also be used to give us things like mini instruction manuals, simple images and so on.

Ouch

Why is pain so painful? After all, it is only nerve impulses sent to our brains like many others. (continued)

Jeremy Greenwood
Bacup, Lancashire, UK

Pain may be considered as both a sensation and an emotion, which is to say that the painful stimulus is directed to more than one part of the brain.

> **"Pain is both a sensation and an emotion, so the painful stimulus is directed to more than one part of the brain"**

It needs to be unpleasant. A person who can't feel pain may not notice that they are leaning on a hotplate until they become aware of a smell of burning.

But pain isn't just a question of avoiding such obvious trauma. Normal daily activities can be damaging. The forces on the knees while walking are one-and-a-half times body weight, and when running or jumping, this force is several times greater.

We continuously adjust activity in small ways that we don't notice, guided by twinges that makes us unconsciously alter behaviour to avoid long-term damage.

The borderlands of pain and emotion are complex and poorly understood, most commonly encountered in those whose pain is out of all proportion to any discernible damage. Their condition is greatly exacerbated by the ignorance and misunderstanding of others. ▮

Answers

Quick quiz #174 *Answers*

1 Argentina. The classification was related to biodiversity
2 *Choloepus*. They are three-toed and two-toed respectively
3 George Emil Palade
4 11
5 The id

Cryptic crossword #94 *Answers*

ACROSS 1 Star map, **5** Cloud, **8** Germanium, **9** Arc, **10** Whey, **11** Tachyon, **13** Unwrap, **15** Cloche, **18** Emeriti, **20** Snob, **22** Bin, **23** Upholster, **24** Guilt, **25** Harvest

DOWN 1 Sigh, **2** Airshow, **3** Meaty, **4** Plinth, **5** Comical, **6** Ovary, **7** Decanter, **12** Superbug, **14** Aliquot, **16** Chortle, **17** Eighth, **19** Ennui, **20** Solar, **21** Frit

#189 Going back in time *Solution*

The time I first looked at the clock was 14:55:41.

The longest interval between palindromic times is 4 hours, 4 minutes and 11 seconds, which happens between 05:55:50 and 10:00:01, and then between 15:55:51 and 20:00:02. The shortest interval of 5 minutes and 10 seconds happens just before and after the hour, for example between 11:55:11 and 12:00:21.

Since my long gap was the second of the day, the time I first looked at the clock was 14:55:41, the next palindrome was at 15:00:51 and the long one began at 15:55:51.

Seeking a soft landing

The elegant structure of a naturally evolved cat's paw has inspired a new way to protect paratroopers' legs. This adventure is sketched in a study called "A 3D-printed sole design bioinspired by cat paw pad and triply periodic minimal surface for improving paratrooper landing protection". The idea is to replace the current kind of shoe soles with something more resembling what one can find by disassembling a cat.

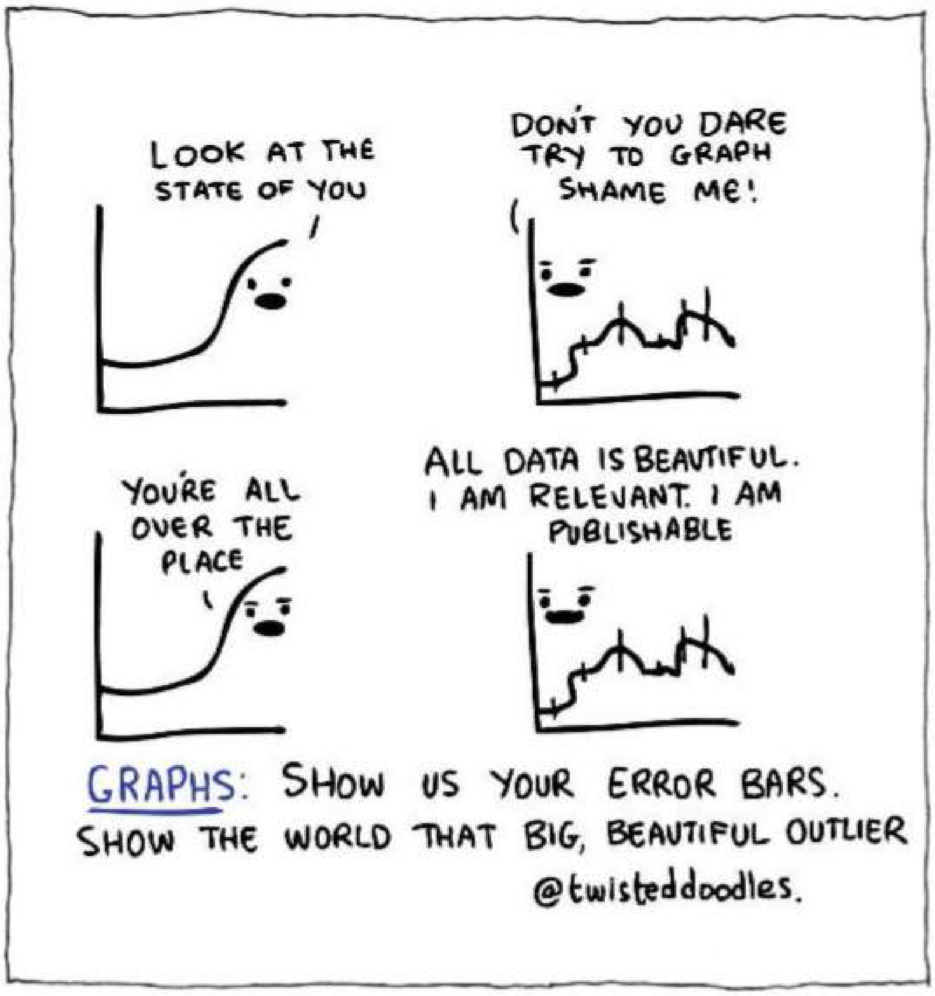
The need is great. Paratroopers, says the study, "have always been the personnel at the highest risk of injury in the military, and their lower extremity injuries account for the highest proportion of parachuting injuries".

The researchers obtained some cats' paws. They analysed the structure, using histological staining techniques, and also micro-CT scans (yes, CAT scans of cats' feet). That guided their attempt "to mimic the adipose tissue found in cat paw pads, which is formed by a subcutaneous layer enclosed within a dermal layer and exhibits typical viscoelastic behavior".

Volunteers were taught to perform a standard half-squat parachute landing manoeuvre. This technique came in handy, so to speak, in a series of drop-landing tests: 10 drops from a height of 40 centimetres and 10 from twice that high. The study reports that the experimental soles were "secured to the subject's feet by adhesive tape" and that the volunteers who had new soles fared fairly well, especially in the higher falls.

The study doesn't dwell on cats' famous ability to land on their feet when some unkind person turns them upside down and drops them from on high. The cat dropping, twisting and landing has been dissected in numerous scientific publications, including this column in years past, and also in many pubs.

Twisteddoodles *for New Scientist*


LOOK AT THE STATE OF YOU
DON'T YOU DARE TRY TO GRAPH SHAME ME!
YOU'RE ALL OVER THE PLACE
ALL DATA IS BEAUTIFUL. I AM RELEVANT. I AM PUBLISHABLE
GRAPHS: SHOW US YOUR ERROR BARS. SHOW THE WORLD THAT BIG, BEAUTIFUL OUTLIER
@twisteddoodles.

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Consideration of items sent in the post will be delayed

A bit Heath Robinson

The cat's-paw-pads-for-paratrooper-protection patent reminds Feedback, a little, of a patent granted to Gustano Pizzo in 1972. Pizzo engineered an electromechanical system to trap aeroplane hijackers. The system first drops a hijacker through trapdoors, seals them into a package, then drops the encapsulated hijacker through the aeroplane's specially installed bomb-bay doors, whence they parachute to earth, where police, having been alerted by radio, await their arrival.

Pizzo's invention is convoluted to a degree reminiscent of the intentionally over-complex devices drawn by cartoonists Heath Robinson and Rube Goldberg. Yet the Pizzo patent has been cited in at least 27 later patents by other inventors. One of them, Wolfgang Gleine's "Aircraft anti-terrorism security system", patented in 2005, shares some – but not all – of the capabilities Pizzo envisioned. Gleine added some new mechanisms: "Alarm signals and terrorist countermeasure devices such as fogging or tranquilizer gas generators, noise generators, high intensity blinding/glaring lights, a cabin lighting master shut-off, window darkening devices, and tranquilizer dart guns".

To airline executives, the Pizzo and Gleine anti-hijacking inventions may have looked too costly, or too advanced. Zoltan Egeresi's patent, granted the year after Gleine's, is an alternative. Egeresi would position a flexible stainless steel net behind the cockpit, hidden under the carpet, connected to four winches. When needed, the net can be "manually activated by the crew to lift up would be hijackers to the ceiling". Alternatively, the machinery can, using two other winches, affix the hijackers to a wall. The patent says the whole system "can be installed on any aircraft". Feedback hasn't found any record of that happening yet.

A Neom ratio sighting

Reader Jason Bradbury sent in the first plausible sighting of the Neom ratio on display somewhere other than in Neom.

The Neom ratio is based on the proportions of a city planned to be built in the Tabuk region of Saudi Arabia. The city is designed to be 170,000 metres long by 200 metres wide. On 1 October, we invited you to tell us about physical objects that have that same proportion (being careful, please, to supply clear examples, and to point to documentation thereof).

Jason writes (accompanied by a spreadsheet of data): "I immediately thought of guitar strings. Using the table of guitar string gauges at Ledger Note, and the guide to the fret spacing of various guitar types at Manchester Guitar Tech, I found that, of the four most common electric guitar scale lengths, only that of the Fender Stratocaster/Telecaster achieves a perfect Neom ratio for effective string length to thickness, and in three instances. With super extra light strings: open A string and G string played on the 12th fret. With medium strings: B string on the 12th fret. Sadly, those three notes make a less than pleasant sounding chord."

Reader Andrew Forsythe sent a good example of how deceivingly difficult it can be to track down a genuine example of the Neom ratio. He writes: "I was hopeful, upon seeing a picture of a giant kidney worm from a coyote, of finding the Neom ratio. But sadly it is not even close. I'd estimate it to have a value of around 100. Too fat by a factor of 8."

FYI, the original Neom ratio specimen is still on display only in plans and publicity materials. It has yet to complete the slim transition from concept to concrete. ▮

Marc Abrahams

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